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News

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DONALD REDDICK, 1883–1955

L. C. Peterson and D. S. Welch

Donald Reddick, Emeritus Professor of Plant Pathology, Cornell University, died in Gainesville, Florida on April 2, 1955.

Dr. Reddick was born in Sheridan, Missouri, on March 1, 1883. In 1905 he received the A.B. degree from Wabash College. In the fall of that year he entered Cornell University and was granted the degree of Ph.D. in 1909.

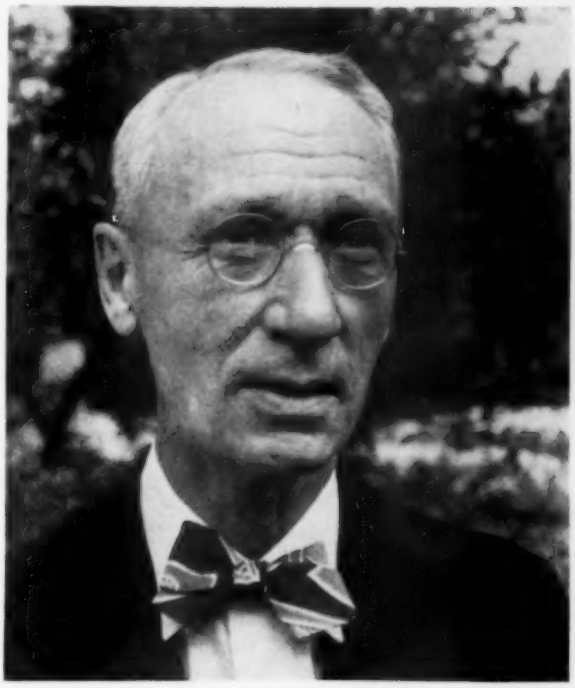
Dr. Reddick was employed at Cornell first as an Assistant in Botany and later as the first Instructor in the newly established Department of Plant Pathology. He was made Assistant Professor in 1909, Professor in 1911, and upon his retirement on December 31, 1950, Emeritus Professor.

At Cornell his first duties included the teaching of graduate courses in mycology and plant pathology. In 1917 he discontinued teaching and began the work he liked the best—research on fundamental problems in plant pathology.

Dr. Reddick's early contributions arose from studies on fruit diseases; his studies on black-rot of grapes have remained to date the outstanding work on this disease. He developed effective practices in the use of fungicides in dust form and is credited with beginning the development of modern methods for the laboratory analysis of new fungicides. He made significant additions to our knowledge of diseases of beans and potatoes. He is best known for his work on late blight of potatoes and for the breeding of potatoes resistant to this disease. In 1930, he conducted a plant exploration trip to Mexico, where he collected wild species with resistance or immunity to *Phytophthora infestans*. These were used in an extensive breeding program. Long and painstaking effort resulted in the production of several varieties of potatoes in which were combined good horticultural qualities and resistance to blight.

Dr. Reddick was among those instrumental in bringing about the recognition in this country of plant pathology as a science. He was a founding member of the American Phytopathological Society. He served the Society as the first Business Manager of PHYTOPATHOLOGY, as Editor (1915-1918), as Councilor (1919), and as President (1920). He also was active in the launching of Botanical Abstracts, serving for two years as Chairman of its Board of Control and editor for plant pathology.

Among the honors that came to Dr. Reddick was the appointment as Secretary of the Plant Pathology Division of the International Botanical Congress in 1926. He served as Vice President of the International Union of Biological Sciences and was for twelve years President of its section for pathology. He was a Fellow of the American Association for the Advancement of Science and served on its council for eight years. He



DONALD REDDICK
1883–1955

was a member of the Society of American Naturalists, Botanical Society of America, Canadian Phytopathological Society, American Association of University Professors, Gamma Alpha, and Sigma Xi, a corresponding member of Nederlandsche Botanische Vereeniging, and a life member of Société Linnéenne de Lyon.

Dr. Reddick's scientific achievements were specifically recognized by citations for meritorious work by the Empire State Potato Club, the Potato Association of America, and the Canadian Phytopathological Society.

In 1909 Dr. Reddick was married to Miss Emma Brill, who died in 1943. The children of this marriage are a son Robert of Ithaca, New York, and two daughters, Emma Louise Thompson, Detroit, Michigan, and Anna Elizabeth Dounce, Rochester, New York. In 1946 Dr. Reddick married Miss Adeline Newman, who survives him.

The personal character of Dr. Reddick was reflected in his research work. His qualities of absolute honesty, his attention to detail, and his high standards were combined with clarity of vision to result in attainments of the highest order. The part that he played in the development and progress of plant pathology is a lasting monument to his life and work.

PHYTOPATHOLOGY for May (46: 243-298) was issued May 17, 1956

PHYSIOLOGIC SPECIALIZATION IN COLLETOTRICHUM LINICOLUM [1]

E. A. Schwinghamer [2]

SUMMARY

Isolates of *Colletotrichum linicolum* comprised many cultural types, some of which were cultural variants. The changes in cultural characteristics were accompanied by a loss in virulence.

The optimum soil temperature for seedling blight of flax was 25–30°C, but the differential response between varieties was most pronounced at a suboptimum temperature of about 15°C.

Inoculation of flax seedlings in the cotyledonary stage with a spore suspension provided the simplest and most selective method of testing isolates for pathogenicity. The best results were obtained with the following conditions: a suspension of approximately 150 spores/cu. mm. a 24-hour exposure in the moist chamber (70°F), and a greenhouse temperature of 60°F. Age of the plants affected the disease reaction in only one (C.I. 1247) of the differential varieties.

With the exception of Crystal, flax varieties grown commercially in the United States proved to be unsatisfactory for differentiating pathogenic races. Six varieties, representing different levels of resistance, were selected as differentials in a screening test of 650 entries of the world collection. These varieties were C.I. 20 (Punjab), C.I. 355 (Ottawa 770B), C.I. 836 (Leona), C.I. 1016, C.I. 1235, and C.I. 1247. By means of these differentials, 42 monoconidial isolates of *C. linicolum* were identified as 5 distinct pathogenic races. On the basis of minor differences, these races were further separable into subraces.

The anthracnose disease of flax, caused by *Colletotrichum linicolum* Pethyb. & Laff., occurs in most of the major flax-growing areas of the world. The prevalence and destructiveness of this disease are dependent on the extensive culture of a susceptible flax variety and on moist, humid growing seasons. The unusual severity of anthracnose on Punjab flax in the Imperial Valley of California in 1940-41 was due to such a combination of conditions (1). In the seed-flax producing areas of the Dakotas, Minnesota, Wisconsin, and Iowa, *C. linicolum* is commonly associated with seedling blight. In surveys of Minnesota flax fields, the prevalence of the fungus in seed ranged from a trace to 60 per cent (3), the severity being usually correlated with the average annual rainfall for the areas concerned.

The seedling blight stage of anthracnose can be controlled by seed treatment (5). Varying degrees of varietal resistance also have been demonstrated, although disease ratings of flax varieties by different workers were based on tests with only 1 or a few isolates of the fungus. The conflicting results sometimes obtained strongly suggested pathogenic variation (4, 6), but experimental evidence for the existence of pathogenic races has not been reported. This paper presents the results of an investigation that demonstrates the occurrence of physiologic specialization in *C. linicolum*.

MATERIALS AND METHODS.—Forty-two monoconidial isolates of *C. linicolum* were used. These were obtained as follows : 30 from Minnesota, 5 from Wisconsin, 1 from California, 3 from Argentina, 2 from Germany, and 1 from Ireland. The Minnesota and Wisconsin isolates were obtained over a 4-year period from diseased flax seed and seedling samples from the main flax-producing areas of these states.

The available portion of the flax world collection (650 entries) was used in pathogenicity tests with 3 isolates. Six differential varieties were ultimately selected to establish pathogenic races, based on the following seedling infection types (Fig. 1):

Resistant (R). Cotyledons and hypocotyls free of lesions or with very small, dark lesions, less than 1 mm in diameter.

Moderately resistant (MR). Lesions (on cotyledons) 1-2 mm in diameter, with well-defined margins; at first dark gray, later becoming tan. Cankers absent from hypocotyls or, if present, dark colored, oval shaped, sharply restricted.

Moderately susceptible (MS). Lesions (on cotyledons) 3 mm or more in diameter, eventually coalescing to envelop entire leaf; dark gray, without sharply outlined margin. Cankers on hypocotyl elongate, orange-brown; seedlings killed under severe conditions.

Susceptible (S). Lesions of unrestricted size on both cotyledons and hypocotyls, coalescing to produce rapid death of seedlings.

Although lesions on both cotyledons and hypocotyls were considered in determining infection types, more emphasis was placed on the former because of greater uniformity in distribution.

Inoculum used in the pathogenicity tests was grown

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Portion of a thesis submitted to the Graduate School, University of Minnesota, in partial fulfillment of the requirements for the degree of Doctor of Philosophy. The work was begun at the University of Minnesota, St. Paul, and completed at the North Dakota Agricultural Experiment Station, Fargo. Paper No. 3468 Scientific Journal Series, University of Minnesota, Agricultural Experiment Station.

[2] Formerly Pathologist, Field Crops Research Branch, Agricultural Research Service, U. S. Department of Agriculture, North Dakota Agricultural Experiment Station. Now with the Biology Department, Brookhaven National Laboratory, Upton, N. Y.

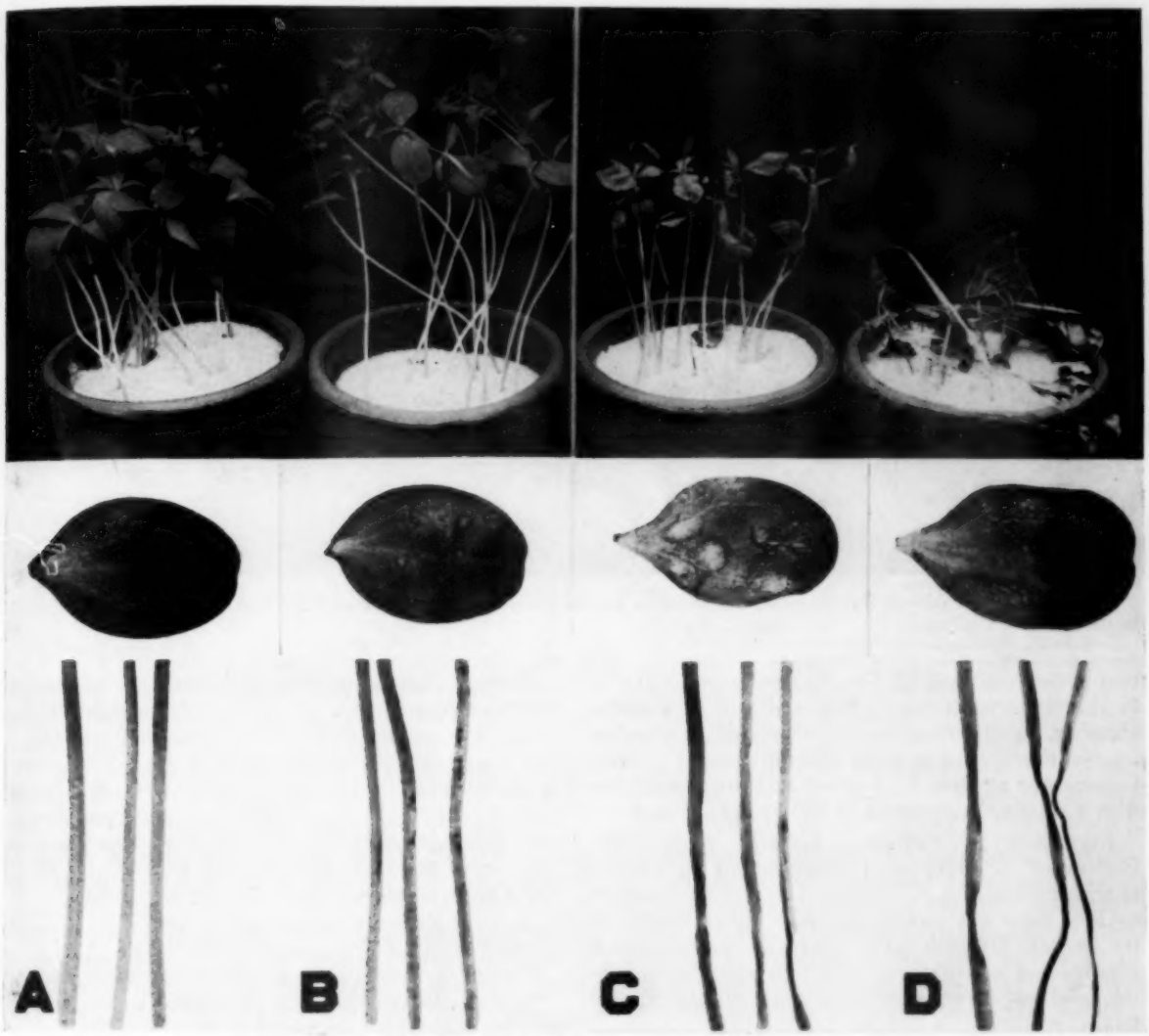

FIG. 1. Infection types produced on flax seedlings by *C. linicolum*. Top to bottom: Seedling symptoms, cotyledon lesions, hypocotyl cankers. A) Resistant (R); B) moderately resistant (MR); C) moderately susceptible (MS); D) susceptible (S).

on potato-dextrose agar or, in the case of sparsely sporulating isolates, on low-nutrient potato-dextrose broth. A water-spore suspension of approximately 150 spores/cu. mm was sprayed on week-old flax seedlings. Gelatin, as a detergent, was used only in adult plant inoculation. The inoculated seedlings were left in the moist chamber for 24 hours at 70°F and then transferred to a greenhouse room where a temperature of 60–65°F was maintained. Infection types were recorded 5 days after inoculation. The race classification for each isolate was based on a minimum of 3 separate experiments, each involving inoculation of 20–40 seedlings, depending on the amount of seed available for each differential variety.

Other methods of inoculation were attempted. In 1 method the seedlings were grown on paper blotters and inoculated by immersion in a water-spore suspension (3). In another procedure the seeds were planted in steamed soil, and the inoculum was poured over the soil. The disease reaction in this case was based on the percentage of blighted seedlings.

A Wisconsin-type soil-temperature tank (2) and the soil infestation method were used for the experiments concerning the effects of soil temperature on the development of seedling blight. Seedling blight in 2 varieties was measured at 5 temperatures, each temperature treatment comprising 3 replicates and 1 check.

A study of factors affecting the disease infection types in race classification was designed to measure the independent effects and the interactions of the following: spore concentration (75, 250, and 800 spores/cu. mm); length of time the inoculated plants were left in the moist chambers (24, 36, and 48 hours); greenhouse temperatures during the incuba-

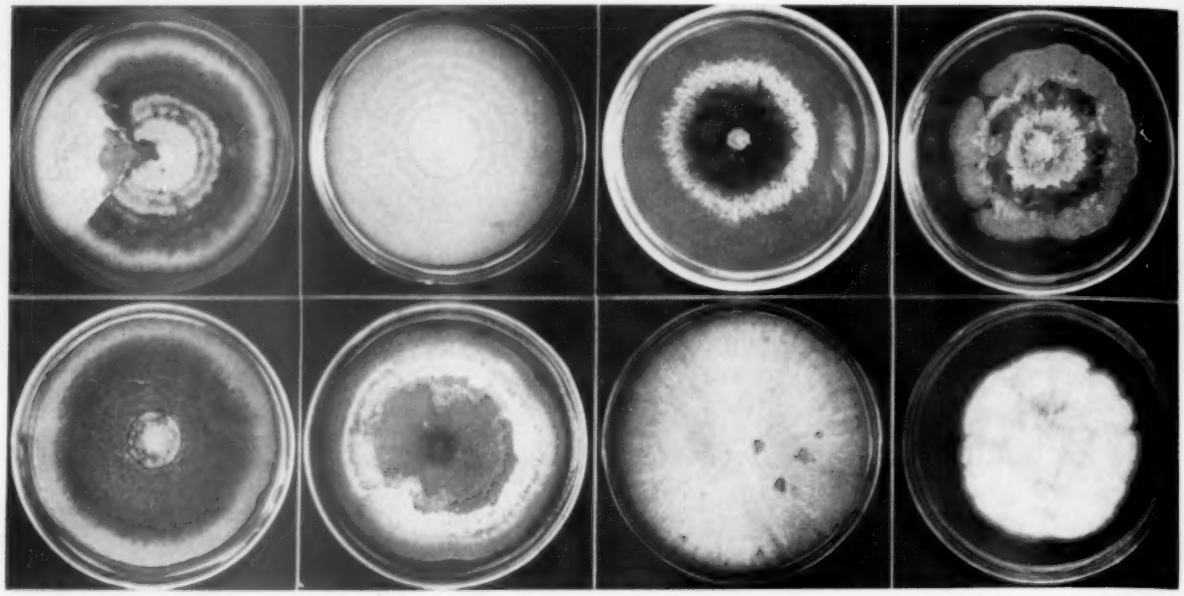

FIG. 2. Monoconidial cultural forms of *C. linicolum* grown on potato-dextrose agar. Typical mycelial sector appears in culture at lower right.

tion period (65° and 75°F). The spore concentration in this experiment was determined with a counting chamber. In the race identification work, a practical degree of accuracy in spore concentration of different isolates was attained by a visual turbidity comparison with a standard suspension of 150 spores/cu. mm.

EXPERIMENTAL RESULTS. — *Cultural types.* — The isolates of *C. linicolum* differed widely in cultural characteristics (Fig. 2), although the orange mycelial-conidial type was clearly the most representative for the species. Mycelial color, marginal zonation, rate of growth, and mycelial growth versus sporulation were the most conspicuous differentiating cultural characters.

Sectors, appearing usually as white appressed mycelial types, occurred occasionally in some of the isolates. In these variants the sparse-sporulation character was associated with a loss in pathogenicity. It was also evident that cultural and pathogenic variants arose most frequently in old, stale cultures. Most of the isolates survived numerous transfers over a period of several years without manifesting any detectable change in cultural or pathogenic characters.

Methods of seedling inoculation.—Inoculation of flax seedlings in the cotyledonary stage by spraying the plants with a dilute spore suspension provided the simplest and most selective method of testing pathogenicity, particularly in race differentiation. Soil infestation and the blotter technique, as substitute methods, proved to be useful in varietal tests involving a larger number of plants, thereby facilitating statistical analysis. The blotter technique was useful for preliminary laboratory tests, but the limited cotyledon development of blotter-grown seedlings rendered it undesirable for accurate pathogenic race classification.

Factors affecting pathogenicity tests.—Temperature had a marked effect on the pathogenicity of the fungus (Fig. 3). Seedling blight (damping-off) reached a maximum at a soil temperature of 25–30°C but was almost completely inhibited at 35°C. The differential response of Punjab and B-5128 was most pronounced at a suboptimum temperature of 15°C. The temperature curve for development on the host closely paralleled the temperature curve for culture growth.

In tests involving inoculation of cotyledons, a spore concentration of approximately 150 spores/cu. mm, a 24-hour exposure in the moist chamber (at 70°F), and a greenhouse temperature of 60°F gave the best results. Partial resistance was masked by a combination of the extreme treatments (800 spores/cu. mm, 48-hour moist chamber exposure, and 75°F greenhouse temperature). Moderately resistant differential varieties, for example, appeared moderately susceptible under such conditions and thus affected the race classification of the isolate concerned. The resistant reaction type was not materially affected by increasingly severe treatments.

The effect of age of the plant on the disease reaction was determined in a comparison of seedling and adult plant reactions. There was close agreement between the cotyledon and true leaf reactions on all the differential varieties except C.I. 1247. This variety manifested increased resistance in the adult plant stage. This was also apparent on cotyledons of the C.I. 1247 seedlings inoculated in the full cotyledonary stage, the 2–4 leaf stage, and the 4–6 leaf stage. An inoculum that gave a moderately susceptible cotyledon reaction on the young seedlings gave a moderately resistant reaction on the oldest ones. Subsequent race studies were therefore based entirely on seedlings

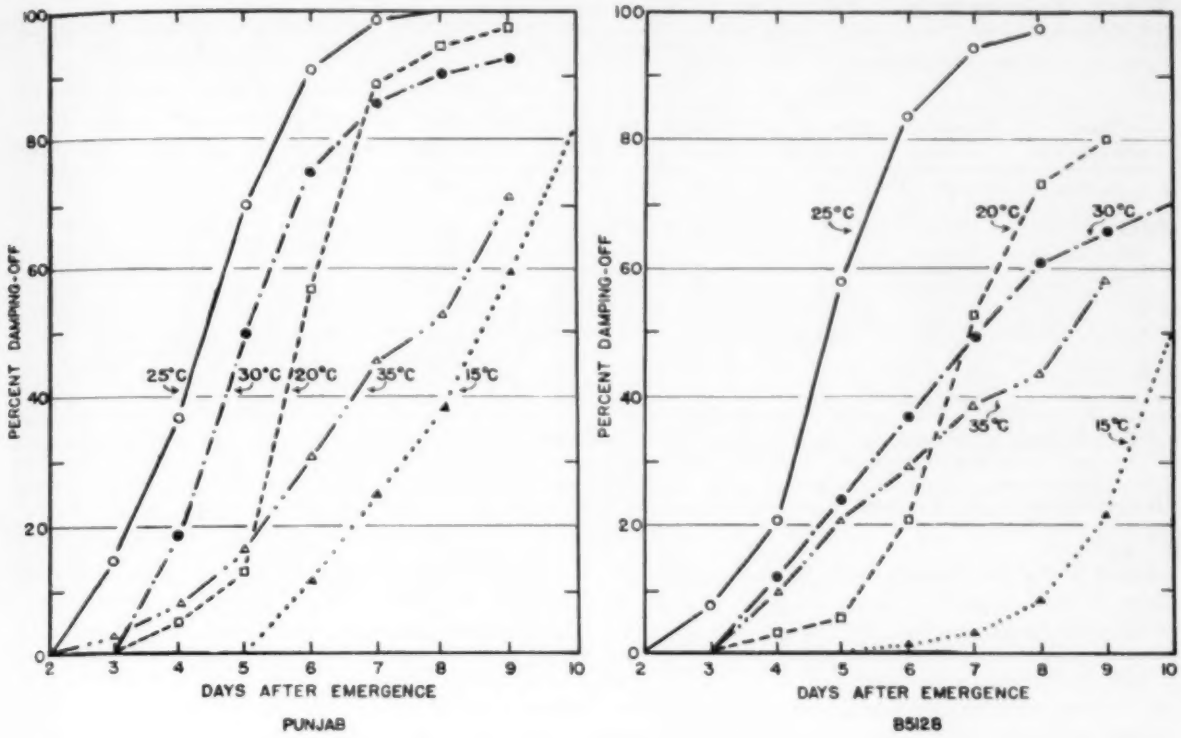

FIG. 3. Effect of soil temperature on seedling blight (damping-off) of 2 flax varieties. The soil was infested with a composite of isolates of *C. linicolum*. Effect at 35°C consisted largely of heat killing.

inoculated in the full cotyledon or 2-leaf stage to avoid erroneous classification of isolates due to this age effect.

Selection of differential varieties.—Initial attempts in differentiating pathogenic races of *C. linicolum* involved the use of commercially grown flax varieties, in addition to varieties like C.I. 326 (Buda), C.I. 463, and C.I. 1009, which have been reported as resistant to anthracnose (6). With a set of varieties selected from this group, it was possible to demonstrate quantitative differences in the percentage of seedling blight and to separate the isolates into 3 arbitrary groups—virulent, moderately pathogenic, and weakly pathogenic (7)—but more than half of the isolates were included in the virulent group. Statistically significant differences in both greenhouse and field experiments were found between the virulent and weakly pathogenic isolates, as well as between Punjab and other varieties. In general, however, these varieties proved to be unsatisfactory as differentials since they failed to distinguish among the virulent isolates. The only exception was the near-immunity of the variety Crystal to virulent isolates from Germany, as contrasted with susceptibility to virulent isolates from Minnesota.

All available entries (650) of the world collection of flax were screened by inoculating the cotyledons with 3 isolates. These isolates, from Minnesota, Ireland, and Germany, were chosen in the hope that geographical diversity in the source of the pathogen might enhance the possibility of a differential response in the host. Thirty-three varieties were classified as highly resistant or as mixtures containing resistant plants; 20 varieties were moderately resistant. Argentine varieties and hybrids or selections produced in the United States predominated in the resistant group, whereas all entries from India and Russia were susceptible. The resistant and moderately resistant varieties selected from this test had reacted similarly to the 3 isolates, but several of these resistant varieties were found to be completely susceptible when inoculated with a fourth isolate (from Minnesota). A set of 6 differentials was selected in a series of inoculations involving the elimination of unsuitable varieties and the addition of more isolates. These differentials and their sources were as follows: Punjab, C.I. 20 (India); Ottawa 770B, C.I. 355 (Canada); C.I. 1016 (Portugal); Leona, C.I. 836 (North Dakota); C.I. 1247 and C.I. 1235 (Argentina).

Pathogenic races.—The results of the pathogenicity experiments are summarized in Table 1, which employs the 4 reaction classes for a close comparison of the degree of varietal resistance or susceptibility. The races, however, are based on the inclusive 2-class system as shown in the dichotomous analytical key of Table 2. As used in the key, "R" includes the R and MR reactions whereas "S" includes MS and S, the division line for race differentiation being between MR and MS. The varieties Punjab and C.I. 1235 were

TABLE 1.—*Pathogenicity levels of 42 isolates of Colletotrichum linicolum on 6 differential flax varieties*

Race and subrace	Source of isolates	Number of isolates	Differential variety[a] and representative disease reaction[b] to each race or subrace					
			C.I. 20 (Punjab)	C.I. 355 (Ottawa 770B)	C.I. 1016	C.I. 836 (Leona)	C.I. 1247	C.I. 1235
1	Germany (2) U.S.A. (4)	6	MS,S	R	MR	R	R	R
2 (a)	U.S.A.	2	S	MS	MR	R,MR	R,MR	R
(b)	Ireland	1	S	MS	MS	R	R	R
3 (a)	U.S.A.	1	S	MR	MR	R	MS	R
(b)	U.S.A.	1	S	MR	MS	R	S	MR
(c)	U.S.A.	5	S	MS	MS	R	S	R,MR
4 (a)	U.S.A.	18	S	MS,S	MR	MS,S	R,MR	R
(b)	U.S.A.	3	S	S	MS	S	R	R
5 (a)	U.S.A.	2	S	MS	MR	MS	MS	R,MR
(b)	Argentina	3	S	MS	MS	MS	MS	MR

[a] C.I. = Cereal investigation accession number, U. S. Department of Agriculture. Variety names are given where known.
[b] R = resistant; MR = moderately resistant; MS = moderately susceptible; S = susceptible. MS,S indicates that Punjab was moderately susceptible to approximately one-half of the isolates of race 1 and susceptible to the other isolates of this race. A single reaction implies predominance of the given type.

omitted in the key because they did not identify any races in the system used here but were retained as differentials because they represented the extremes in susceptibility and resistance, respectively.

The 42 isolates were identified as 5 races, 4 of which were separated by Leona and C.I. 1247. These races were easily distinguishable because the difference in host reaction was decisive, from R to MS or S, and vice versa. Four of the races could be further separated into 9 subraces on Ottawa 770B and C.I. 1016. The reactions of these 2 varieties usually differed only from MR to MS.

DISCUSSION.—Like many other fungus species, *Colletotrichum linicolum* consists of biotypes that differ in pathogenicity as well as in cultural characters. The number of pathogenic biotypes that can be identified is clearly dependent on the number of isolates, the number of differentials, and the system of classification used. From a practical standpoint, however, it is significant that the isolates in this study could be placed in a relatively small number of readily identifiable races. This fact favors the breeding of flax varieties for resistance to the prevalent races of *C. linicolum*. C.I. 1235, as already mentioned, was highly resistant to most of the isolates. Leona and C.I. 1247 reacted reciprocally to isolates of 4 of the 5 races, and hybrids of these 2 varieties might provide resistance to all the isolates except those from Argentina. Despite this apparently fortuitous situation, it is perhaps also significant that whereas some of the most resistant varieties in the world collection originated in Argentina, the isolates obtained from that country were also among the most virulent. The problem of inheritance of resistance to *C. linicolum* was investigated in a series of crosses made between the differential varieties. The F_1 and F_2 progenies were tested with isolates representing appropriate races. A preliminary evaluation of the data indicates that the high degree of resistance found in some of the Argentine varieties is governed by only 1 or 2 factor pairs, whereas the inheritance of the intermediate types of resistance appears to be more complex. Results of this study will be published at a later date.

The perfect stage of *C. linicolum* is not known, hence the existence of pathogenic variation focuses some attention on the question of how these races originated. In a recent experiment, the susceptible variety Punjab was heavily inoculated with a composite of all available isolates to explore the possibility of heterothallism. The infected plant material was overwintered, but it yielded no evidence of the ascigerous stage. Similarly, there was no evidence of perithecial formation when such a composite of spores was sprayed on agar media. The frequent occurrence of cultural variants in old, stale media suggests that mutations for pathogenicity might similarly originate in senile or dead host tissue. This possibility was not experimentally exploited.

TABLE 2.—*Dichotomous analytical key to pathogenic races of Colletotrichum linicolum*

Leona, resistant—"R"
  C.I. 1247, resistant
    Ottawa 770B, resistant
      C.I. 1016, resistant 1
    Ottawa 770B, susceptible—"S"
      C.I. 1016, resistant ..... 2 (a)
      C.I. 1016, susceptible ..... 2 (b)
  C.I. 1247, susceptible
    Ottawa 770B, resistant
      C.I. 1016, resistant ..... 3 (a)
      C.I. 1016, susceptible ..... 3 (b)
    Ottawa 770B, susceptible
      C.I. 1016, susceptible ..... 3 (c)
Leona, susceptible
  C.I. 1247, resistant
    Ottawa 770B, susceptible
      C.I. 1016, resistant ..... 4 (a)
      C.I. 1016, susceptible ..... 4 (b)
  C.I. 1247, susceptible
    Ottawa 770B, susceptible
      C.I. 1016, resistant ..... 5 (a)
      C.I. 1016, susceptible ..... 5 (b)

Cultural types were associated to some extent with the general level of virulence but not with specific host reaction. For this reason the validity of the pathogenic races was not significantly affected by the occurrence of cultural mutants that were accompanied by a loss in level of virulence. The isolates known to be of the mutant type were all included in the most avirulent race group. The other groups were composed of isolates that generally did not differ greatly in cultural form and were not known as mutants.

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SEVERAL OAT VARIETIES RESISTANT TO NATURAL INFECTION BY LEPTOSPHAERIA AVENARIA [1]

R. L. Kiesling and J. E. Grafius [2]

SUMMARY

Forty oat varieties were selected from a total of 5343 lines of the World Oat Collection for their resistance to the black-stem and leaf-blotch phases of Septoria disease (caused by *Leptosphaeria avenaria* Weber) under Michigan conditions. These selections were tested for 3 years and remained highly resistant under conditions of natural infection. The susceptible check was heavily infected during all 3 years. The resistant varieties represent a range of maturity dates and agronomic types suitable for the Michigan oat-breeding program. Resistance to stem and leaf blotch functioned independently in certain varieties. Slight variation in disease reactions occurred on some varieties in different years and areas of the state, but on the whole the reactions of the varieties were highly consistent.

The Septoria disease of oats caused by *Leptosphaeria avenaria* Weber (*Septoria avenae* Frank) is a widespread and important oat disease in Michigan. Black stem is the most common and important symptom of this disease of oats in Michigan, although *L. avenaria* causes a leaf blotch and a kernel blight on oats.[3,4,5]

Septoria leaf blotch occurs frequently on the leaves of susceptible oat varieties, but damage is more severe if leaf infection is followed by invasion of the sheath and culm tissues and the subsequent development of black stem. Kernel blight is more important in the processing of oats for food than in the disease cycle.[6,7] Blighted seedlings were grown from infected seed, but these blighted seedlings appeared to outgrow the seedling phase of the disease.[7]

Varietal resistance is reported, but most of the varieties tested were only moderately resistant to *L. avenaria*.[3] Therefore, the World Oat Collection was examined for new sources of resistance to *L. avenaria* for use in the Michigan oat-breeding program.[8] Selection of oat varieties resistant to *L. avenaria* will per-

[1] Accepted for publication January 11, 1956.
Contribution No. 55-11 from the Department of Botany and Plant Pathology.

[2] Assistant Professor of Plant Pathology and Associate Professor of Farm Crops, respectively.

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[6] Huffman, M. D. 1955. Disease cycle of Septoria disease of oats. Phytopathology 45: 278-280.

[7] Lund, S., and H. L. Shands. 1955. Seedling infection of oats caused by Septoria avenae. Phytopathology 45: 181-182.

[8] This work was started by Dr. K. Frey, formerly of the Farm Crops Department, Michigan State University.

mit the study of possible biological specialization of the pathogen.

MATERIALS AND METHODS.—Black-stem resistant varieties were selected from the World Oat Collection of the U. S. Department of Agriculture grown at East Lansing from 1951 through 1953. A very susceptible line, A 700-17 (Andrew X Landhafer), was selected for use as a susceptible check variety. In 1954, those Septoria-resistant varieties selected in 1953 from the World Oat Collection were grown at East Lansing and re-evaluated for both black-stem resistance and agronomic characteristics, i.e., stiff straw, kernel type, and maturity date. Forty varieties from the 1954 trials were planted in yield trials in the Ingham, Tuscola, Lenawee, and Kalamazoo county oat nurseries in 1955.

Readings of disease severity were taken at comparable stages of host development to avoid confusing lateness with resistance to black stem. Black-stem readings were taken when the culms were mature and straw-colored, and leaf-blotch readings were made just after the plants had headed. Readings were based on the reaction of all the plants within a 12-ft. row, with the scale of readings ranging from 1 (no infection) to 5 (severe infection).

TABLE 1.—*Reaction*[a] *of spring oat varieties to Leptosphaeria avenaria*

No.[b]	Leaf-blotch reaction		Black-stem reaction		
	1954[c]	1955[d]	1953[c]	1954[c]	1955[d]
1062	2	1	1	1	1
1415	1	1	1	1	1
1618	1	2—	1	1	1
2070	1	2—	1	1	1
2392	1	2—	1	2—	1
4682	1	2—	1	2—	1
4729	2	2	1	2—	1
4758	2	1	1	2—	1
4890	1	1	1	1	1
4898	1	2	1	2—	1
4900	2	2	1	2—	1
4960	2	2—	1	2—	1
4961	2	2—	1	2—	1
4998	1	2—	1	2—	1
5031	1	1	1	2—	2
5037	1	1	1	1	1
5038	1	2	1	1	1
5039	3	3—	1	1	1
5044	2	2—	1	2—	1
5047	2	1	1	1	1
5048	2	2—	1	1	1
5049	2	2—	1	1	1
5050	2	2	1	1	1
5053	2	2—	1	2—	2—
5055	1	1	1	2—	1
5056	1	1	1	1	1
5083	1	1	1	2—	2
5093	1	2—	1	2—	2
5101	1	2—	1	1	1
5103	2	2—	1	1	2—
5156	1	1	1	1	1
5157	2	2—	1	2—	2—
5161	1	1	1	1	1
5163	1	2	1	1	1
5165	2	2—	1	1	1
5179	1	1	1	2—	1
5240	1	1	1	1	1
5258	1	1	1	1	1
5260	1	1	1	2—	1
5335	1	1	1	1	1
A700-17	4	4	4	5	4

[a] Disease reactions were rated on a scale from 1 (no infection) to 5 (severe infection).

[b] Except for A700-17, numbers are accession numbers of the Cereal Crops Section of the Agricultural Research Service, U. S. Department of Agriculture.

[c] Data from 1 location only.

[d] Data are averages of readings from 4 locations.

RESULTS.—Heavy natural infections were obtained at all locations as is shown by the high leaf- and stem-blight readings for the susceptible check (Table 1). In contrast, the varieties selected for resistance showed consistently lower ratings. Nine of the varieties tested from 1953–1955 were very resistant to black stem and leaf blotch under Michigan conditions (Table 1).

Susceptibility to leaf blight and black stem functioned separately. The variety C.I. 5039 was susceptible to leaf blight but highly resistant to black stem at all 4 locations. C.I. 5083 and 5031 were resistant to leaf blight but susceptible to black stem at several locations. In some varieties, leaf lesions occurred at the base of the leaf blade and advanced down into the leaf sheath, but back stem lesions failed to develop under the infected sheath. On these resistant varieties, leaf blotch was confined to the lower leaves, and no lesions developed on the upper culm, leaves, or panicle.

The percentage and severity of the infection by *L. avenaria* on some of the resistant varieties varied slightly with the seasons. All of the resistant varieties tested in 1955 were rated as highly resistant in 1953, but in 1954 half of these varieties showed short narrow lesions on the culm base just above the ground line. In the 1955 trials, 13 of the varieties that had trace infections in 1954 were free of lesions, but the varieties C.I. 5103, 5031, 5083, and 5093 showed greater black stem incidence in the 1955 trials. In general, the resistant varieties were consistent in reaction over the 3-year period and appear to be good sources of genes for resistance to *L. avenaria*.

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THE EFFECTS OF TEMPERATURE AND MOISTURE ON THE SPREAD OF WHITE PINE BLISTER RUST[1]

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SUMMARY

To increase our understanding of how temperature and moisture influence the spread of the white pine blister rust fungus, studies were made of the influence of these factors in relation to the production and germinability of the spores of *Cronartium ribicola* Fischer.

Aecial pustules appeared in 7 days after cankers were brought into the greenhouse in late winter. They opened and released viable spores several hours after they were placed in a fog chamber. Day lengths of from 11.5 to 24 hours and temperatures of from 16° to 28°C failed to alter the time required for aeciospore production. On agar made with dilute Ribes-leaf decoction, aeciospores germinated well from 8° to 24°, with the optimum near 16°.

Production of urediospores and teliospores was studied chiefly on inoculated plants of *Ribes nigrum*. Supplementary data were obtained from 4 species of Ribes native to Wisconsin. On all species, urediospores formed under conditions ranging from a day temperature of 16°C combined with a night temperature of 2° through day and night temperatures of 28° and 20°, respectively, but they did not form when the day temperature was 35° (5- to 7-hour day). In most cases, 20 days at a day temperature of 35° prevented subsequent sporulation of the fungus; even 10 days delayed and limited uredial development considerably in all cases and prevented it in many.

Urediospores germinated well on all substrates at temperatures from 16° to 28° C, with the optimum at 20°. Free water was necessary for germination on Ribes leaves. Four to 6 hours were required for urediospores to begin germination.

A 2-week period of suitable temperatures was required before the first appearance of fertile teliospores. These 2 weeks are called the formation period. Ribes-leaf maturity was not an important factor in the time of teliospore production; the period. Ribes-leaf maturity was not an important was the dominant influence on the time when teliospores were produced. Whereas a constant temperature of 20° allowed the formation of teliospores in the greenhouse, any normal field temperature range in which the nights were as warm as 20° prevented teliospore formation; day temperatures of 35° completely prevented their formation despite low night temperatures.

Temperature during the formation period markedly influenced the viability of teliospores. They were more sensitive to temperature during the formation stage than afterward. With constant temperatures, those produced at 16° germinated from 4° through 20°; those produced at 20° were erratic in their germination; and those produced at 24° were practically sterile. With varying temperatures, formation of teliospores continued at day temperatures up to 28°, but those formed at day temperatures of 24° and 28° were practically sterile. Teliospores that had formed on wild Ribes plants in the field in a 3-week period of approximately 15°–25° weather were practically sterile. They remained sterile through 20°–35° temperatures. After 1 week of temperatures under 20°, however, fertile teliospores were found. Teliospores from another site also showed low fertility when produced late in the season during a period of 28°–30° day temperatures and 5°–15° night temperatures. In another location, 3 days with 28°–32° maxima were enough to produce sterility despite 8°–18° night temperatures.

The temperatures to which previously formed teliospores were exposed also affected their capacity for germination. High temperatures inhibited germination; e.g. 5 days of 35° weather eliminated the chances for infection for 7 or 8 days thereafter.

The temperature in which teliospores were formed also influenced the sporidial germination time. With teliospores formed in a constant 16° temperature, 42–48 hours were required for formation and germination of sporidia; if 2° night temperatures were substituted in the teliospore-formation period, 36 hours were enough.

The spread of blister rust in Wisconsin was limited principally by the lack of sufficient moisture for sporidial formation and germination. When periods of saturated air occurred, a prior period of 2 weeks with no 3 consecutive days over 28°C became important to provide production of fertile teliospores. For subsequent infection on pine, the period of 48 hours of saturated air required temperatures under 20°.

To understand better where and how white pine blister rust develops, a clarification of the intimate climatic conditions necessary for its spread and survival has appeared essential. Such knowledge might make it possible to forecast where serious infection would be most likely to occur. Thus it would assist the men who plant white pine as well as those who protect it by means of Ribes eradication. Some possibilities have already been indicated by Hirt (4, 6), Riker et al (9), and Spaulding (12). Many indications have appeared that warm, dry weather might inhibit the rust.

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The historical record of the spread of blister rust (caused by *Cronartium ribicola* Fischer) on white pine provides some presumptive evidence. Blister rust remained static in warm, dry parts of Europe while spreading rapidly in the cooler, more moist northwestern part (12). It was introduced on nursery stock at various points in eastern North America from 1900 to 1915. In New England and New York, the rust began rapid westward spread from the points of introduction into Ontario. The introduction into western Wisconsin resulted in a rapid spread both east and west; however, where the disease was introduced into the warmer sites of Virginia, Indiana, and Ohio, it spread little (11, 12). In the western part of North America, where the disease spread from a single point of introduction in British Columbia, it moved much more rapidly eastward into the western white pine region than it did southward into the sugar pine region, where temperatures were higher and relative humidities were lower (2). The history of the spread of white pine blister rust through most of the white pine regions was reviewed by Boyce (2), Meilke (8), and Spaulding (11, 12). They noted rapid spread of the disease through cool, moist regions and stasis in warmer and dryer regions.

Both kinds of regions occur in Wisconsin. Southwestern Wisconsin is in the prairie or prairie-border region of America, characterized by relatively dry winters and severe summer drought. Northern Wisconsin is in the northeastern forest region, which is characterized by relatively snowy winters and reliable summer rains (1). Many species of plants are limited to 1 part of the state or the other. Blister rust seems largely limited to the northern region except for local cooler sites. Much of the eastern white pine in the prairie-border region of southern Wisconsin has escaped infection by the white pine blister rust fungus. Only a small percentage of the trees were diseased, although dense Ribes concentrations were close by, and the rust has been present in some areas 17–25 years (7). The rust remained confined to limited areas even during "wave" infection years such as 1941 and 1944. Sauk County still had this type of localized distribution 25 years after the first infection. In contrast, in cooler and more moist northern Wisconsin, infection on white pine could be found on almost any site near Ribes. In Oneida County, for example, where rust also has been present for 25 years, almost all sites had some rust in 1953, and trees on most sites were heavily infected. In southern Wisconsin, the blister rust cankers found were less than 8 ft. above the ground. In northern Wisconsin, however, cankers often were found on any part of the tree.

The distribution of blister rust in Wisconsin as correlated with climate and microclimate is discussed elsewhere (14). Those sites where blister rust was present on pine in southern Wisconsin had air temperature less than 20°C and had higher relative humidities and longer periods when the air was saturated with moisture than did those of adjacent areas. Such favorable infection sites were at the bases of slopes, in sheltered valleys, and in openings in the forest (15).

The purposes of the study reported in this paper were to improve definition of the effect of temperature and humidity on the development of different spore types and thus on the spread of the blister rust fungus and to establish an improved basis for evaluating the chances of infection at given sites.

MATERIALS AND METHODS.—Blister rust fungus "cultures" used in these studies were made from spores collected from uredia on wild Ribes bushes or from aecia on cankers brought into the greenhouse in late winter. Mixtures were used, with no effort made to keep various collections separate. The rust fungus was maintained through the year in the uredial stage on Ribes plants in the greenhouse at approximately 26°C.

The environmental conditions required for the production of the various spore stages were determined in experiments in which infected host plants were grown under controlled temperature and moisture conditions.

Potted Ribes plants were used in temperature and moisture studies. These plants were grown from cuttings or from wild plants transplanted from the woods. In these experiments, at least 2 replications were made with plants of *Ribes nigrum* L., and 1 or more replications were made with each of the 4 native species used; viz., *Ribes cynosbati* L., *R. americanum* Mill., *R. hirtellum* Michx., or *R. missouriense* Nutt. All 5 Ribes species grew well in the greenhouse in winter when added artificial light gave a day length of 16 hours. Red spiders were controlled ordinarily by malathion and miscible tetraethyl pyrophosphate sprays. Both sprays injured any rust fungus spores present, so the spiders were washed off with water as spore-collecting time approached.

The effects of different temperatures on spore production were tested by placing infected host material in greenhouses with controlled temperatures and in special chambers. Greenhouse temperatures were maintained within 1°C. Fluctuating temperatures were obtained by moving diseased plants from one greenhouse to another in various combinations of time and temperature or by fluctuating the temperature in special chambers to approximate natural late-summer diurnal variation. A 2° cold room was used for the lowest night temperatures.

Spore germination tests were made on water agar, Ribes-leaf-decoction agar, water, and Ribes leaves. Temperatures for spore germination tests in Petri dishes were obtained in laboratory incubators. For plant inoculation studies, moisture was provided for germinating spores by compressed-air atomizers in chambers in the greenhouses of different temperatures. These sprays kept the chambers constantly filled with fog but were not enough to wash off the spores.

RESULTS.—*Aeciospore production and germination.*—Groups of 10–17 naturally infected pine branches were collected from 5 locations in the state—2 loca-

tions in the north and 3 in the south. Cankers were collected in late winter while snow was on the ground and aecial pustules were not detectable. The branches were set in cans of water in the greenhouse. To keep the branches fresh, a 1-in. length of the butt was cut off each branch every other day and the water changed.

One can of cut branches containing 3–5 cankers was placed in each greenhouse at 16°, 20°, 24°, and 28°C. Natural day length in these greenhouses was 11.5–13.5 hours.

Two cans of cut branches, each with 3–5 cankers, were exposed to day lengths (periods of light that were longer than normal). One can kept at 26° had a 15-hour light period. One can at 21° for 12 hours and at 10° for 12 hours had 24 hours of light.

The complete experiment as described was repeated twice, and trials with the 3 different day lengths (at 24° in the 12.5-hour day) 3 more times. Since the results from the various collections were similar, they were not reported separately.

None of the temperature or photoperiod treatments affected the length of time required for production of aeciospores. Young aecia were detectable under the bark when cross sections were examined with a hand lens within 4 days after the cankers were brought into the greenhouse. Aecial pustules showed on most of the cankers in 7 days and on nearly all the remaining few cankers in 8 days. Some small cankers never produced aecia.

Moisture appeared important. The aecial blisters did not open in the dry air of the greenhouses. Some were opened mechanically and the spores tested; germination was poor. In 7 subsequent germination trials, the cankers containing aecia were placed in a fog chamber where the aecia opened naturally. The aeciospores were shed after a few hours. These aeciospores germinated well in the tests. Extremely hot (up to 33°C) dry weather in southern Wisconsin the last part of April and the first week in May did not prevent natural aecial discharge in 1952. Thus, either short exposures to saturated air provided in the moist chamber or the moist night air in the woods was sufficient for successful aeciospore discharge.

To test aeciospore germination, 8 trials were set up with different substrates. Four trials were made with 2.5 per cent water agar, 1 with activated charcoal in the agar, and 3 with Ribes-leaf-decoction agar. The leaf decoction was prepared from 325 g of leaves of *R. nigrum* per liter of water and was used in dilutions of 1/2–1/256 of this concentration (pH 4.5). Results showed that dilute (1/64 and 1/128) leaf-decoction agar was the best medium; activated charcoal inhibited germination.

The effect of constant temperature on aeciospore germination on agar was tested. The large majority of aeciospore germinations occurred from 8° to 24° with the optimum near 16° (Fig. 1). Germination tests with 11,000 spores in additional trials on water agar showed that a period of chilling at 0° or exposure to temperatures as high as 36° for 8 or 9 hours was somewhat stimulating (13).

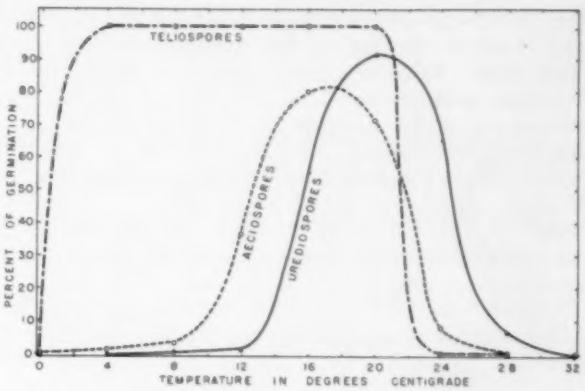

FIG. 1. Germination of spores of the white pine blister rust fungus as affected by temperature. Hirt (4) showed that basidia and sporidia were not produced above 21°C, and sporidia did not germinate above 20°.

The effect of temperature on the germination of aeciospores *in vivo* was checked by inoculating 12 plants of *R. nigrum* and 4 of *R. cynosbati* in fog chambers. Eight leaves were inoculated on each of these 16 plants. Each replication consisted of 4 plants, 1 such plant incubated in each of 4 temperatures—cool (16°–17°), moderate (18°–20°), warm (21°–24°), and hot (25°–28°). Results of Ribes inoculations corresponded with those obtained from aeciospore germinations on agar. The average percentage of leaf area bearing rust pustules was 38, 63, 56, and 14 on plants incubated in the cool, moderate, warm, and hot temperatures, respectively.

Urediospore and teliospore formation.—Spore production as affected by day and night temperature was observed on 50 Ribes plants. Approximately 8 leaves were inoculated on each plant of the following species: 37 bushes of *Ribes nigrum*, 6 of *R. cynosbati*, 3 of *R. hirtellum*, 2 of *R. americanum*, and 2 of *R. missouriense*.

Data on the time of urediospore and teliospore production at various day and night temperature combinations are summarized in Figure 2. A representative example is plant 1, *R. nigrum*, held for the first 28 days at a day temperature of 16° and a night temperature of 2° and then for 6 days at 16° day and night. Incipient symptoms (flecks) and a few uredia appeared the 15th day, uredia predominated on the 16th day, and urediospores appeared on the 17th day after inoculation. Teliospores were evident the 26th day but were abundant only on the 29th day and thence to the end of the test.

The plants in Figure 2 are arranged in groups with those from the lowest temperature range placed at the top of the figure. The first series (plants 1–4, 16–19) show the development at 16°–28° day temperatures and 2° night temperatures. The appearance of flecks, uredia, and urediospores occurred progressively faster as the daytime temperature was increased. Teliospores developed in all cases where the night temperature

was 2°. In general, profuse teliospore production was slower at the higher day temperatures than at lower ones. Teliospore production was slower with 2° night temperatures than with 14° or 16° night temperatures. An example of spore production in this lower temperature range is plant 18, *R. americanum* (Fig. 2) kept at a 24° day temperature and a 2° night temperature for 29 days. Incipient flecking symptoms appeared after 12 days, uredia after 16 days, and urediospores after 18 days. A few teliospores were evident after 21 days, but an abundance of teliospores was not present until the 26th day.

The middle range of temperatures was tested on plants 33, 35, 32, 11, 26, 27, 28, 24, 9, 10, 61, and 62 (Fig. 2). The production of urediospores occurred in the shortest time after inoculation on plants in this range. Plants in a constant 16° temperature produced urediospores later than those at a 24° day temperature and a 16° night temperature. The uredial stage occurred about as soon on plants at a 24° day temperature and a 16° night temperature as on plants at a 28° day temperature and a 20° night temperature. When plants in this group were moved to a greenhouse at a 35° day temperature, urediospores did not form. Moreover, those formed previously at a lower temperature showed a rapid decline in fertility when the plant was moved to a 35° day temperature. Plant 28, *R. hirtellum*, was kept at 26° day and night for 12 days, then subjected to 8-hour days at 35°, 8-hour nights at 26°, and 4-hour morning and evening periods at intermediate temperatures. The lesions began to turn brown and die 6 days after the plant was moved to the 35° day temperature. On the 26th day, 4 days after the return to more moderate temperatures, a few urediospores were visible on the edges of the gray-brown necrotic areas, and urediospores were produced in the living areas of the leaves for the rest of the 34 days. Plant 24, *R. cynosbati*, had a history much like that of plant 28, *R. hirtellum*, except that the rust fungus never recovered to produce urediospores again. The difference in ability to recover from the effects of the 35° day temperatures was noted frequently and seemed to be partly a host reaction, all leaves on the entire plant responding similarly.

Teliospore production on the plants in this middle range (Fig. 2, plants 33, 35, 32, 11, 26, 27, 28, 24, 9, 10, 61, 62) occurred in all cases where the night temperature was 16° or less. Teliospores were produced most rapidly (about 21 days) at 16° day and night. When the first week was at 26° day and night, teliospores developed as rapidly as when the full 3 weeks were at 16°. Rapid teliospore production occurred when day and night temperatures were 24° and 16°, respectively. Teliospores did not form if the night temperature was 20° or warmer, or if the day temperature was 35°. They appeared slowly at a 28° day temperature.

The effects of different periods of exposure to 35° day temperatures were shown on plants 63–68, 5–8, 12–15 (Fig. 2). Even 3 days of such high temperature delayed the appearance of urediospores, and urediospores were few in number. Longer exposures caused greater delays. Plants 5–8 and 12–15 were tests of 35° day temperature with night temperatures from 16° to 28°. Some of these plants were exposed briefly to higher temperatures, as noted. Rust development on the plants in the high temperature ranges (plants 28, 24, 63–68, 5–8, 12–15) showed that the rust fungus in Ribes leaves apparently was killed, or severely inhibited, by 10 to 15 days' exposure to 35° day temperature. If symptoms did develop subsequently, they were only traces.

Urediospore germination.— The germination of urediospores from plants of *R. nigrum* and *R. cynosbati* was tested in distilled water, on water agar, and on Ribes leaves at different temperatures. All germination tests were made in Petri dishes. Those containing Ribes leaves were kept moist by wet paper toweling. These dishes were incubated at constant temperatures of 0°, 4°, 8°, 12°, . . . 36°C. Spore germination was counted with a microscope at 100× magnification. Several random fields of 30–100 spores were counted for each medium at each temperature. When spores were germinated on Ribes leaves, stomata were closed (leaves were incubated in the dark), and spores germinated only when in contact with free water on the leaf surface. Urediospores germinated well on all substrates at temperatures of 16°–28°, with the optimum near 20° (Fig. 1).

The first germination was noted at 4 hours, and most spores had started germination by 6 hours.

Teliospore germination and fertility.—Since the telial columns were sometimes sterile, a study of their ability to produce sporidia was essential. First, the effects of different constant temperatures during teliospore formation on the fertility of telial columns were investigated. *R. nigrum* and *R. cynosbati* were placed in greenhouses kept at constant temperatures of 16°, 20°, and 24°C prior to the time teliospores

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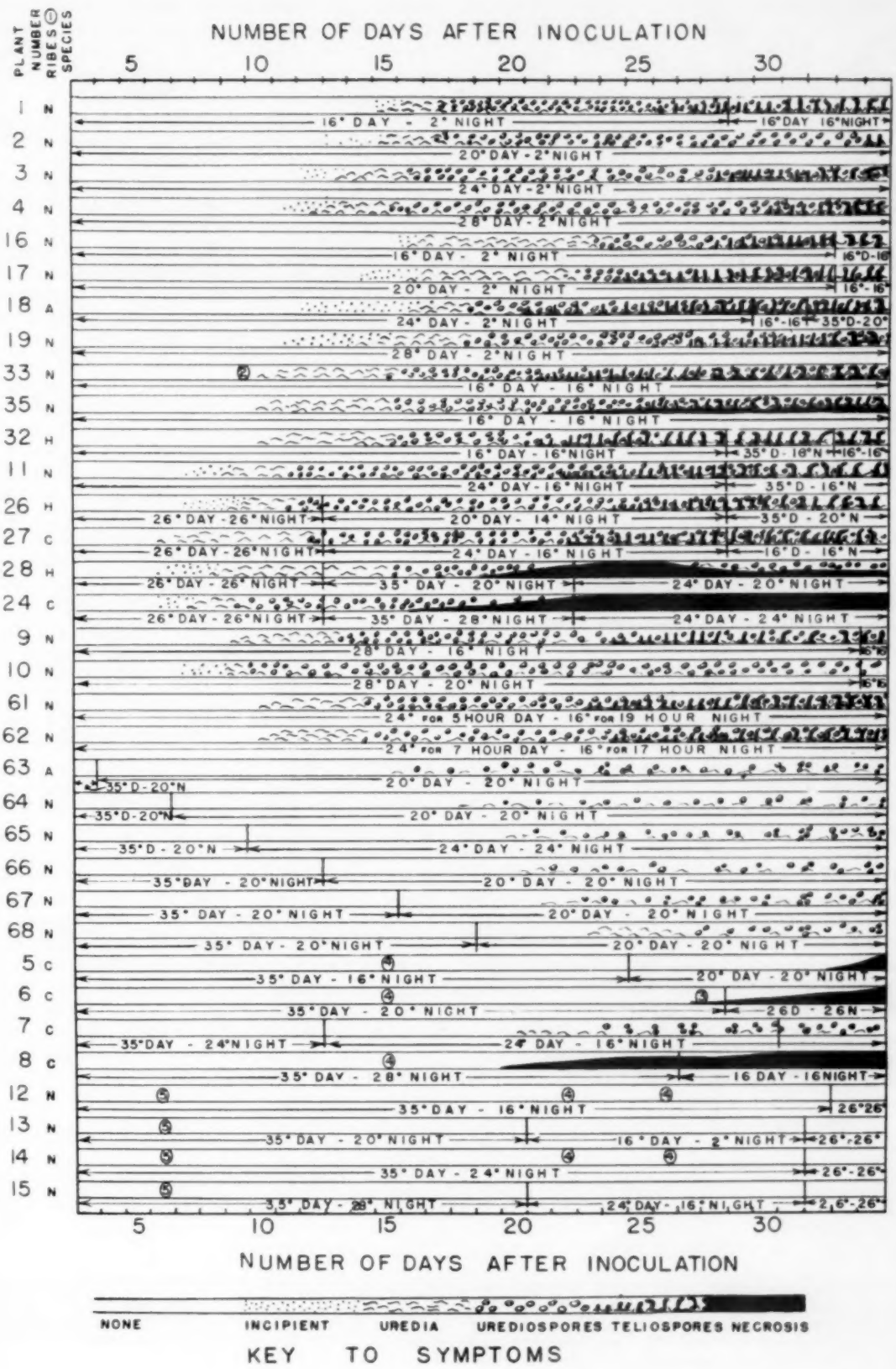
FIG. 2. The development of blister rust on Ribes plants exposed to various day and night temperatures. Circled numbers indicate the following: 1) Ribes species used were N, *R. nigrum;* C, *R. cynosbati;* A, *R. americanum;* and H, *R. hirtellum.* 2) Observations were made every other day; in some cases uredia developed so rapidly that incipient stage was not observed. 3) The plant developed urediospores after 38 days. 4) The plant was subjected to a temperature greater than 38°C for 2 hours on this day. 5) The plant was subjected to a temperature greater than 38°C for 1 hour on this day.


PLANT NUMBER
RIBES SPECIES
NUMBER OF DAYS AFTER INOCULATION
5 10 15 20 25 30
1 N
2 N
3 N
4 N
16 N
17 N
18 A
19 N
33 N
35 N
32 H
11 N
26 H
27 C
28 H
24 C
9 N
10 N
61 N
62 N
63 A
64 N
65 N
66 N
67 N
68 N
5 C
6 C
7 C
8 C
12 N
13 N
14 N
15 N
16° DAY - 2° NIGHT
16° DAY 16° NIGHT
20° DAY - 2° NIGHT
24° DAY - 2° NIGHT
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26° DAY - 26° NIGHT
24° DAY - 16° NIGHT
26° DAY - 26° NIGHT
35° DAY - 20° NIGHT
26° DAY - 26° NIGHT
35° DAY - 28° NIGHT
28° DAY - 16° NIGHT
28° DAY - 20° NIGHT
24° FOR 5 HOUR DAY - 16° FOR 19 HOUR NIGHT
24° FOR 7 HOUR DAY - 16° FOR 17 HOUR NIGHT
35°D-20°N
20° DAY - 20° NIGHT
35°D-20°N
20° DAY - 20° NIGHT
35°D - 20°N
24° DAY - 24° NIGHT
35° DAY - 20° NIGHT
20° DAY - 20° NIGHT
35° DAY - 20° NIGHT
20° DAY - 20° NIGHT
35° DAY - 20° NIGHT
20° DAY - 20° NIGHT
35° DAY - 16° NIGHT
20° DAY - 20° NIGHT
35° DAY - 20° NIGHT
26D - 26N
35° DAY - 24° NIGHT
24° DAY - 16° NIGHT
35° DAY - 28° NIGHT
16 DAY - 16 NIGHT
35° DAY - 16° NIGHT
26°-26°
35° DAY - 20° NIGHT
16° DAY - 2° NIGHT
26°-26°
35° DAY - 24° NIGHT
26°-26°
35° DAY - 28° NIGHT
24° DAY - 16° NIGHT
26°-26°
NUMBER OF DAYS AFTER INOCULATION
NONE
INCIPIENT
UREDIA
UREDIOSPORES
TELIOSPORES
NECROSIS
KEY TO SYMPTOMS

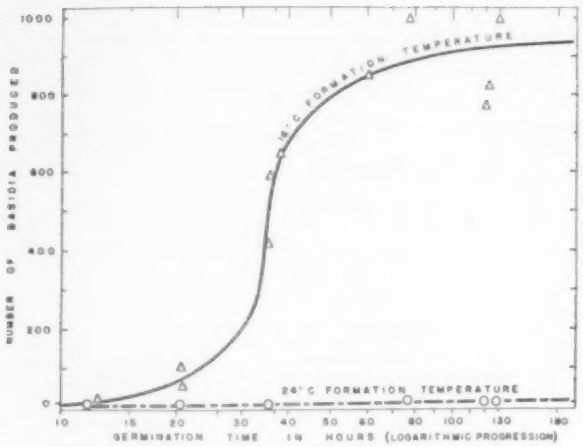

FIG. 3. The germination at 20°C of teliospores formed at constant 16° and 24° temperatures.

were visible. After their first appearance, telial columns were allowed to grow for 24–48 hours, then 8 telia were picked from 2 or more leaves at each temperature and placed on water agar in a Petri dish. The telia that formed at each temperature were incubated at that temperature and at each of the other 2 temperatures to check the relation of germination temperature to formation temperature. Furthermore, in 3 trials, telia were incubated at temperatures 0°, 4°, 8°, . . . 32°. Two samples were chilled at 0° for 12 hours and later germinated.

Teliospore germination and fertility were measured by counts or estimates of the numbers of basidia and sporidia produced. If only a few basidia were visible as the telial columns lay flat on the agar surface, they were counted. If larger numbers of basidia were present, estimates were made. If over 1000 basidia were visible, germination was considered complete and recorded as 1000. Similarly, sporidia were counted if the numbers were small; otherwise the number was estimated in accordance with the average number of sporidia to each basidium; e.g. a column in which the teliospores were germinating very well might have 1000 basidia and about 3 sporidia to each basidium, so 3000 sporidia were recorded for the column.

The temperature at which the telial column was formed had a marked effect on the subsequent germination of the teliospores (Fig. 3). Germination at 20° demonstrated these effects most noticeably. Telia that formed at 16° and germinated at 20° produced large numbers of basidia, with 3000–4000 sporidia produced by each telial column. In contrast, those that formed at 20° were erratic in their ability to produce basidia and sporidia (therefore not shown in graph), whereas those formed at 24° produced very few basidia, and only 1 attached sporidium was seen.

Telia that formed at 24°, if then detached and held at 16° in air saturated with moisture for 10–11 days, produced large numbers of sporidia. This period of time necessary for recovery, however, is just as long as the time required for the development of new fertile teliospores on Ribes plants; hence the importance of the inhibitory effect of high formation-temperatures is not lessened by this ability of recovery.

Since a constant high temperature during the formation stage decreased fertility of teliospores so markedly, the effect of fluctuating temperatures on teliospore fertility was studied. The histories of 17 representative plants (continued from Figure 2) subjected to fluctuating temperatures are shown in Figure 4. Teliospore fertility is represented by the number of sporidia produced. In the assessment of fertility, the germination counts for 8 telial columns were averaged for each plant, as in the constant-temperature studies. Teliospores were germinated at 16° for 25–50 hours.

As an example, plant 1 (*R. nigrum*) was given a 16° day temperature and a 2° night temperature for 28 days after inoculation (the temperatures for the first 20 days can be seen in Figure 2). The next 10 days were at 16° day and night. The plant was then exposed to a 35° day temperature (8-hour day) and a 20° night temperature for 10 days. On the last day, the inoculated plant was subjected to 2 hours at 36°, 2 hours at 37°, and 2 hours at 38°. Fertility tests were made at the end of each period. The second and third days after telia appeared, teliospores in these short, young telia produced about 70 sporidia on each day. By the ninth day, the telia columns had lengthened and upon germination produced a full quota of sporidia (represented by a count of 3000, or 3 full bars in Figure 4). The subsequent exposure to a 35° day temperature caused a decline in fertility from about 1500 sporidia at the end of the first day of high temperature to 50 on the eighth. On the 47th day after inoculation, when the temperature was raised to 38°, continued low fertility was evident from

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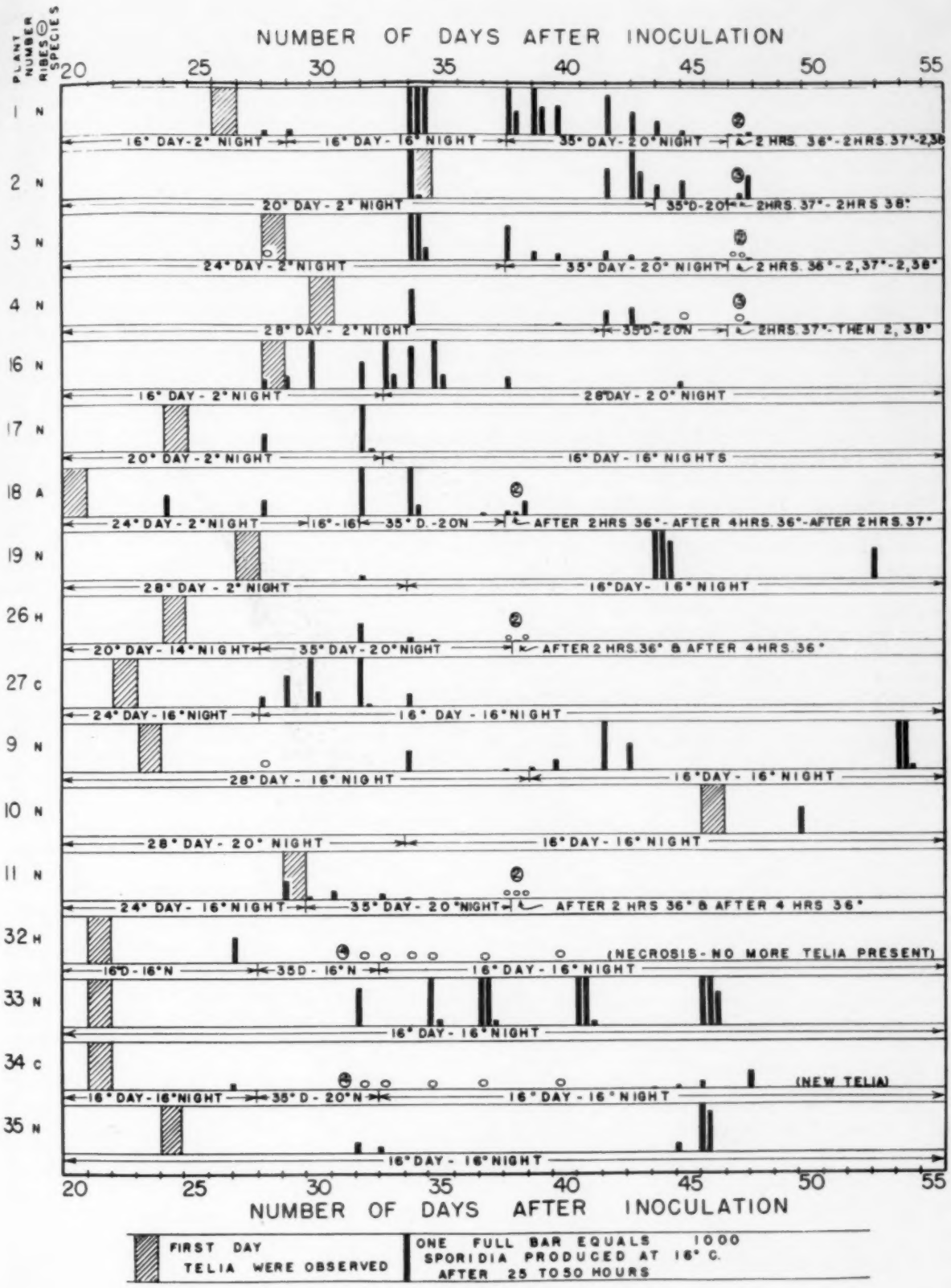
FIG. 4. Teliospore fertility (represented by number of sporidia produced) as affected by the period of exposure to different day and night temperatures. Circled numbers indicate the following: 1) Ribes species used were N, *R. nigrum*; A, *R. americanum*; H, *R. hirtellum*; and C, *R. cynosbati*. 2) Three tests were made on this day after the periods of temperature exposure indicated. 3) Two tests were made on this day after the periods of temperature exposure indicated. 4) The plant was exposed to 38°C for 1 hour on this day.


NUMBER OF DAYS AFTER INOCULATION
PLANT NUMBER
RIBES SPECIES
20 25 30 35 40 45 50 55
1 N
16° DAY-2° NIGHT
16° DAY-16° NIGHT
35° DAY-20° NIGHT
2 HRS. 36°-2HRS.37°-2,38
2 N
20° DAY-2° NIGHT
35°D-20N
2HRS.37°-2HRS 38°
3 N
24° DAY-2° NIGHT
35° DAY-20° NIGHT
2 HRS. 36°-2,37°-2,38°
4 N
28° DAY-2° NIGHT
35D-20N
2HRS.37°-THEN 2,38°
16 N
16° DAY-2° NIGHT
28°DAY-20° NIGHT
17 N
20° DAY-2° NIGHT
16° DAY-16° NIGHTS
18 A
24° DAY-2° NIGHT
16°-16
35° D.-20N
AFTER 2HRS 36°-AFTER 4HRS.36°-AFTER 2HRS.37°
19 N
28° DAY-2° NIGHT
16°DAY-16° NIGHT
26 H
20° DAY-14° NIGHT
35° DAY-20° NIGHT
AFTER 2 HRS.36° & AFTER 4HRS.36°
27 C
24° DAY-16° NIGHT
16° DAY-16° NIGHT
9 N
28° DAY-16° NIGHT
16°DAY-16° NIGHT
10 N
28° DAY-20° NIGHT
16° DAY-16° NIGHT
11 N
24° DAY-16° NIGHT
35° DAY-20° NIGHT
AFTER 2 HRS 36° & AFTER 4 HRS 36°
32 H
(NECROSIS-NO MORE TELIA PRESENT)
16D-16N
35D-16N
16° DAY-16° NIGHT
33 N
16° DAY-16° NIGHT
34 C
(NEW TELIA)
16° DAY-16° NIGHT
35° D-20°N
16° DAY-16° NIGHT
35 N
16° DAY-16° NIGHT
20 25 30 35 40 45 50 55
NUMBER OF DAYS AFTER INOCULATION
FIRST DAY TELIA WERE OBSERVED
ONE FULL BAR EQUALS 1000 SPORIDIA PRODUCED AT 16° C. AFTER 25 TO 50 HOURS
KEY

the production of only 2–8 sporidia that were never cast from the basidia. This inhibition was greater with plant 4, which was exposed to a high day temperature (28°) with low night temperature (2°) for 42 days. It produced only 700 sporidia per telial column on the 34th day and decreased steadily in production to 38 on the 40th day. After 3 days at a 35° day temperature and a 20° night temperature, no sporidia were produced. The more rapid advance of sterility as the temperature was raised was typical of plants on which telia formed at higher temperatures.

The reduced fertility of teliospores at 24° and 28° day temperatures (12-hour days) with low night temperatures was seen on plants 3, 4, 18, 19, and 11. Teliospores that lost their fertility by exposure to 35° day temperatures (plants 1, 2, 3, 4, 32, 34) apparently were killed and never recovered the ability to produce sporidia. Teliospores that had fertility reduced by exposure to 24° or 28° recovered the ability to produce sporidia in cool temperatures. Plant 9, with 2200 sporidia per telium after 2 weeks of 16° weather, is a good example of this.

In general, the rust fungus on plants subjected to low night temperatures produced telia, but if day temperatures were relatively high (about 24° or above), the teliospores had greatly reduced fertility. Fertile teliospores were never produced on plants exposed to warm night temperature (20°) or on those subjected to a day temperature of 28°, and no teliospores were produced on plants subjected to a day temperature of 35°.

To define still more precisely the effects of time and temperature on teliospore fertility, shorter periods of exposure were tried. One plant each was exposed to periods of 2, 4, and 6 12-hour days at 28° and to nights at 20° in the last week prior to teliospore formation. A control plant was kept at a constant 16°. Telia on the plant given the 2-day treatment produced only 1/5 as many sporidia as those on the control; telia from the plants given the 4- and 6-day treatments produced less than 1/10 as many sporidia as the control.

In another experiment, plants of *R. nigrum* (10 in all) were subjected to day-temperature periods of 3–9 hours. On all 6 plants subjected to short-day temperatures of 24° or 28° with 16° nights during the teliospore-formation period, teliospores were much reduced in fertility compared with those formed at a constant 16°. Fertility of teliospores produced on the 9-hour-day plant was reduced the most; telia produced less than 1/6 the number of sporidia produced by telia from the control plant. The number of sporidia from telia developed on plants given 3-hour days of 24° or 28° was reduced about ¾; fertility of the spores from the 28° plant was only slightly less than that of spores from the 24° plant.

Germination tests of teliospores formed on naturally infected wild Ribes bushes next to which hygrothermographs had been installed demonstrated that 3 days of warm weather (with 3 hours in each day at 28–32°) in the formation stage resulted in sterile teliospores. One day at 32° did not cause such sterility (Fig. 5).

High temperature during the teliospore-formation period affected the type of subsequent germination of these teliospores. Not only were few sporidia formed, but they often remained attached to the basidium. If sporidia were cast, they were unable to germinate normally, producing short, blunt, abnormal-looking germ tubes.

Chilling the telial columns at 0° for 12 hours delayed germination greatly in some cases and prevented production of sporidia in other trials. Results were irregular. Although detrimental, chilling did not act to prevent completely sporidial production.

Teliospore production at different temperatures and the effects of such temperatures on subsequent fertility also were observed on wild Ribes plants in nature. Hygrothermographs were placed in shelters with the measuring elements 20 in. above the ground among numerous Ribes bushes infected by the rust fungus. Teliospores were plucked from nearby leaves exposed to the same microclimate and were germinated in sets of 8, as in other tests, at 8°, 12°, and 16°. The numbers of basidia formed, sporidia formed, sporidia cast, and sporidia germinated were counted or estimated. Data on the fertility of teliospores collected during the summer of 1953 in the field and germinated on water agar at 12° are summarized in Figure 5. Teliospores that had been formed during 3 weeks of approximately 15°–25° weather and collected August 21 were practically sterile. Continued sterility was observed through the next 13 days of 20°–35° weather. One week after the drop to cool weather (under 20°), fertile teliospores were found. Subsequent warm weather caused reduction in fertility. Figure 5 shows this phenomenon in 2 locations. Teliospores from another site, in Forest County, also showed low fertility at 28°–30° day temperatures with low night temperatures (approximately 5°–15°).

An influence of sunlight on fertility was observed. Teliospores produced on plants in the Dane County plot (in the sun) showed a greater reduction in fertility than those from the Rock County site (in the shade) during warm October weather. This effect probably came from the bright sunlight period. Teliospores formed in sunny weather in the greenhouse at 24° and 28° day temperatures (February, 1954) were completely sterile, whereas those formed in cloudy weather (March, 1954) at the same or higher temperatures retained some ability to produce sporidia. Leaves in the sun are often as much as 10° warmer than the surrounding air (16).

The germination percentage of teliospores dropped quite sharply (Fig. 1) between 20° and 24°. Observations at intermediate points have been reported by Hirt (4). He found that sporidia were not produced above 21° and did not germinate above 20°.

Leaf maturity did not significantly affect the time required for telial formation. In all of the 5 constant-temperature trials, telia were formed in 14 or 15 days after plants were moved from the 26° house to the

16°, 20°, or 24° houses. Telia were formed almost simultaneously on all of the inoculated leaves (approximately 15) from the bottom of the plant to the top. On some plants in later experiments, telia formed

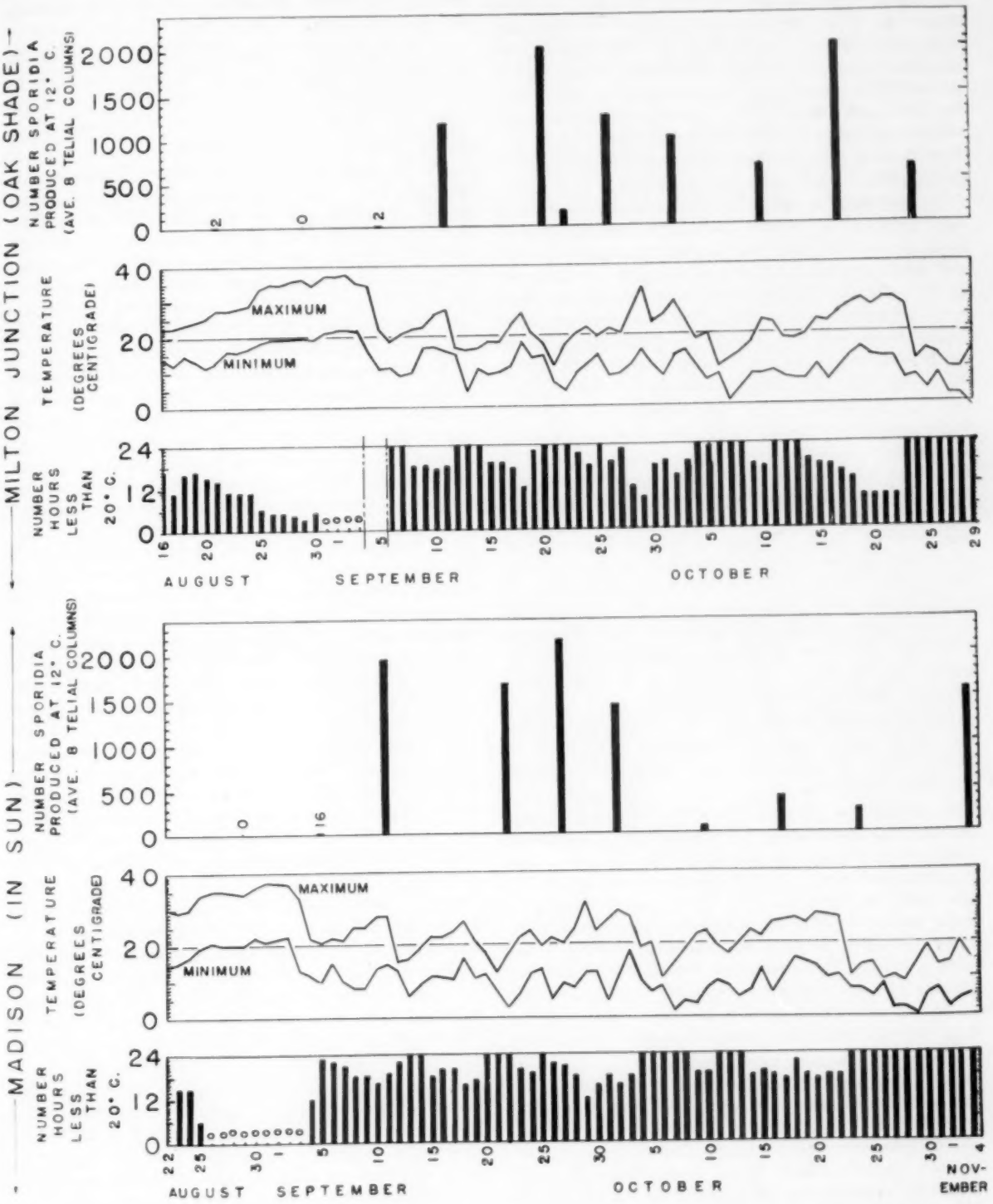


FIG. 5. The influence of prior temperatures upon the subsequent fertility of teliospores collected from wild Ribes at 2 different sites in southern Wisconsin (1953). At Milton Junction, teliospores were from *R. cynosbati*; at Madison, they were from *R. nigrum*.

1–2 days earlier on bottom leaves, which were 2–3 weeks older than those at the top.

The temperature during the first week after inoculation did not seem to affect the time required for teliospores to form. Teliospores formed 3 weeks after inoculation, whether plants were held at constant 16° or moved from a high (26°) to a lower temperature at the end of the first week. Since the temperature during the first week did not affect teliospore formation, the teliospore-formation period was considered to be the 2 weeks prior to the first appearance of teliospores on the Ribes leaf.

To find the time necessary for sporidial production and germination in an atmosphere saturated with moisture at 16°, teliospores were germinated while still attached to Ribes plants growing in a greenhouse at 16°. Leaves bearing suitable telia were fastened with adhesive tape to the aluminum lids of Petri dishes above 1.5 per cent agar. Petri dish bottoms containing fresh agar were placed under the covers at 6-hour intervals to test the rate of sporidia castings.

Telia produced at a 16° day temperature and a 2° night temperature and those formed at a constant 16° temperature were used in the germination tests. From telia formed under the first conditions, a few sporidia were cast, and a very few had started to germinate at the end of 36 hours. The bulk of the germination started at 36 hours. Telia that formed at a constant 16° had produced a few sporidia at 36 hours; sporidial germination began at about 42 hours. The graph of basidial formation in Figure 3 shows the type of increase characteristic of that in sporidial discharge. Detached telia used in teliospore tests such as those summarized in Figures 4 and 5 all germinated slower than the attached telia in these 2 tests.

In 1952 and 1953, exposure to a single wet cool day (continual light rain) of teliospores formed on attached leaves of wild Ribes was insufficient to induce sporidial production.

In 1954, the germination of teliospores of low fertility was observed on Ribes plants during a period (September 12–16) of nearly continuous rain when temperatures were under 20°. The last hot day (35.5°) had been on September 6. Germination results of these spores in the laboratory indicated that teliospores collected at noon on September 14 were completely sterile. Those collected September 15 had low fertility—80 sporidia per telial column after 48 hours at 12° in air saturated with moisture. Thus, in the field, teliospores had not germinated after 3 wet days.

These germination records indicated that 36 hours at 16° in an atmosphere saturated with moisture was the minimum time required to initiate significant sporidial production, casting, and subsequent germination. Higher temperature ranges than 2° night temperatures caused slower spore production. Freezing inhibited production. Germination at 30 hours was only 1 per cent of that at 48 hours. If the temperature during the formation of telia was constantly as warm as 16°, then 42–48 hours was necessary for sporidial production and germination. If 2° night temperatures were substituted in the telial formation period, however, only 36 hours was required. Such germination, of course, must take place before any infection of pine can occur.

Discussion.—The complicated life cycle of the blister rust fungus requires favorable weather for completion; however, examinations at various stages show that certain spores are much more sensitive than others to moisture and temperature.

In the work with moisture, certain limitations appeared. The hair hygrometers available were not considered fully reliable when the relative humidity was over 90 per cent. In this study, the air was considered saturated when free moisture was maintained on a plant or container, or when a hair hygrometer showed 100 per cent relative humidity. If the leaf temperature was cooled below the dew point by radiation, water condensed on the leaf.

Since aeciospore production occurs over a wide range of temperatures and with a few hours of saturated air, such as occurs overnight, aeciospore production probably is not a limiting factor in the spread of rust during Wisconsin spring weather. Aeciospores are the most durable spores of the fungus, lasting several weeks under dry conditions and in exceptional cases as long as 6 months (3, 10, 11); however, 8 hours of direct sunlight reduces viability to 1 in 2000 (11). Aeciospores germinate over a wide range of temperatures; brief freezing or high temperatures, such as are likely to occur in the spring, stimulate germination. The germination temperatures shown in this paper are higher and extend over a broader range than those reported by Doran (3), but Hirt (5) also reported that aeciospores germinated readily at higher temperatures and that Ribes plants were successfully inoculated with aeciospores in a damp chamber that was always at least 2° warmer than the upper limit set by Doran (19°). Free water and saturated air were necessary for aeciospore germination and Ribes infection; 5–25 hours was required depending on the temperature (3, 11, 13).

Urediospore formation occurred at constant 16° to 28° temperatures (9). Whereas temperature ranges tested did not show the lower limits of urediospore formation, 35° day temperatures did prevent it. Formation was slower at the lower temperatures. The time after inoculation required for urediospore production reported here was about the same range as other reports (11), although no temperature range gave as fast a production as the fastest reported (7 days).

Rapid reductions in urediospore viability as the spores became older was noted by Spaulding (11). After 3 days, less than ½ the spores germinated and practically none after 2 weeks; however, Spaulding (11) reported exceptional cases of spores lasting up to 270 days.

The temperatures at which urediospores germinated as reported herewith were over a greater range and at higher temperatures than those reported by Doran

(3). Likewise, Spaulding (11) noted that infection of Ribes plants could occur at the higher temperatures. Perhaps the washing and shaking treatments used by Doran in preparing the spores reduced the high-temperature germinations. Doran apparently obtained only low germination percentages.

Free water on the leaf surface and a saturated atmosphere were necessary for urediospore germination and Ribes infection (11). Work reported herewith confirmed the necessity of free water on a Ribes leaf.

The minimum time required for germination of urediospores, with first germination noted at 4 hours and most spores starting to germinate by 6 hours, is slightly less than the 5½ hours reported by Doran (3), whereas Riker et al (9) noted increasing Ribes infection each hour from 5 to 12 hours.

The information on urediospore formation and germination indicates that a period of 4–12 hours of fairly warm saturated air with free water present on the leaves is necessary for uredial infection of Ribes plants. In Wisconsin a period of warm weather is needed for infection. Dewy nights usually occur during the coolest part of the 24-hour period. Low night temperatures at 20 in. above the ground are usually less than 16° and frequently are less than 12°. In 1951, for example, the weather was generally too cool in southern Wisconsin for much uredial spread.

The temperature during the period of formation of teliospores was an especially important consideration. As the formation temperature decreased, teliospore fertility increased, until the detrimental freezing point was reached. In contrast, daily temperatures ranging from 15° to 25° were warm enough to prevent the formation of fertile teliospores in the wild. After temperatures had once favored the production of fertile teliospores, and inhibiting warm temperatures had intervened, only a week of cool weather was necessary for the production of fertile teliospores. This is the usual case in September in Wisconsin. Two weeks of weather in which less than 3 consecutive days exceed 28° is apparently necessary for the first production of fertile teliospores.

According to Hirt (4), normal teliospore germination (formation of basidia) occurred from 0°–1° through 21°. Hirt reported also that a few teliospores germinated at 22° but never produced sporidia. In the present work, a very few abnormal nonfertile basidia formed at 24°.

Germination of sporidia was affected by both temperature and moisture. Normal sporidial germination was reported to occur at 0°–1° to 20° (4). Within this range, the lower the temperature the higher was the germination percentage, but the higher the temperature the faster the germ tube grew. Hirt (4) said, "For the best germination, sporidia required 100 per cent relative humidity or direct contact with water." Germination was less as humidity was reduced until only a few sporidia germinated at 97 per cent relative humidity, and none germinated at less than 97 per cent. For sporidial germination in the Adirondacks in New York, Hirt (6) considered rain the most important source of moisture. Dew allowed the production of some sporidia, but it dried before germination could occur; thus dew alone was inadequate for suitable inoculum when a prolonged cool, moist period occurred.

The duration of the period of cool, wet weather required for infection of pine is the cumulative time required for the production of basidia, production of sporidia, casting of the sporidia, germination of the sporidia, and penetration of the pine needle by sporidia. On the basis of the data presented in this paper, the minimum time until sporidial germination occurs is considered to be 36 hours. According to Hirt (6), an additional period of 11 or 12 hours is required for penetration. In 1952, 1953, and 1954, continually checked teliospores in the wild showed practically no sporidial production from a single wet, cool day. It was concluded that 2 days (48 hours) with a maximum temperature of 20° and with saturated air are necessary for infection of pine.

Searches of weather records resulted in the conclusion that the spread of blister rust in Wisconsin is limited principally by the lack of sufficient moisture for sporidial formation and germination (14). In addition, a primary requirement for the production of fertile teliospores is a period of 2 weeks with no 3 consecutive days over 28°C. For subsequent sporidial formation and germination, and ensuing infection of pine, a period of 48 hours of saturated air is required with temperatures under 20°.

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PHYSIOLOGICAL RACES OF ERYSIPHE GRAMINIS F. SP. HORDEI IN NORTH AMERICA [1]

J. G. Moseman [2]

SUMMARY

Six new physiological races of *Erysiphe graminis* DC. f. sp. *hordei* Em. Marchal and 9 other previously reported physiological races of this species were isolated from diseased plants obtained throughout North America from 1950 to 1954. These races were distinguished on the basis of their pathogenicity on the differential varieties Black Hulless, Chevron, Goldfoil, Heil Hanna 3, Nepal, and Peruvian. They were compared also with 13 races previously found in North America, 3 races isolated in Japan, and 2 races found in Argentina.

The geographic distribution of physiological races isolated from plants grown in North America was determined. The pathogenicity of 49 cultures from conidia and 151 cultures from cleistothecia was tested. The cultures isolated from ascospores in cleistothecia were found to vary more in pathogenicity than those isolated from conidia.

The inadequacies of the present differential varieties for determining pathogenic variation for use in breeding programs and the advantages of using as differentials individual genes for resistance in the host are discussed.

The first extensive studies on physiological specialization of the powdery mildew fungus, *Erysiphe graminis* DC., were made by Neger (13) in 1901. He found that within a morphological species there are forms which are limited to 1 host plant or to closely related host plants. He concluded that conidia produced on one host species will not infect host species of another genus, but occasionally they infect other species of the same genus.

In 1902, Em. Marchal (10) distinguished and named, on the basis of host specialization, the following 7 formae speciales of *E. graminis: tritici* on species of *Triticum; hordei* on species of *Hordeum; secalis* on species of *Secale; avenae* on species of *Avena* and on *Arrhenatherum elatius* (L.) Presl; *poae* on species of *Poa; agropyri* on species of *Agropyron;* and *bromi* on species of *Bromus.*

Mains and Dietz (8) first demonstrated the existence of physiological races of *Erysiphe graminis* f. sp. *hordei.* They distinguished 5 races of the organism by using the following 4 differential varieties: Black Hulless (C. I. 666),[3] Goldfoil (C. I. 928), Nepal (C. I. 595), and Peruvian (C. I. 935). They also reported the reaction of the variety Heil Hanna 3 (C. I. 682).

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Approved by the Director of the North Carolina Agricultural Experiment Station. Cooperative investigations of the Field Crops Research Branch, Agricultural Research Service, U. S. Department of Agriculture, and the North Carolina Agricultural Experiment Station.
Appreciation is expressed to Dr. G. A. Wiebe for furnishing the barley seed, to the many investigators who sent the diseased plants, and to Dr. C. W. Schaller who supplied 3 cultures of the powdery mildew fungus from California.
[2] Pathologist, Field Crops Research Branch, Agricultural Research Service, U. S. Department of Agriculture.

[3] C. I. refers to the accession number of the Cereal Crops Section.

These 5 varieties were used by Tidd (18) to describe races 6 and 7 in 1937. Newton and Cherewick (14) and Cherewick (1) found 5 additional races in Canada. In these studies, they used a sixth differential variety, Chevron (C. I. 1111). The reaction of the Chevron variety could be correlated with the earlier work, since Mains and Martini (9) gave its reaction to races 1, 2, and 3, and Tidd (18) listed its reaction to races 6 and 7. Cherewick (1) isolated a culture that fitted the description of race 4, to which Chevron gave a type zero reaction. Jensen (7) isolated a culture in New York State that fitted the description of race 4 based on the first 5 differential varieties. In contrast to Cherewick's isolate, Jensen's culture produced a type 2–3 reaction on Chevron. Jensen (7) also reported a race that is different from the 12 races reported by other investigators in North America.

Favret (3) and Sarasola, Favret, and Vallega (17) found 2 races in Argentina that were distinct from the races reported in North America. In Japan, Hiura and Heta (4) isolated 2 biotypes of race 8 found in North America and 3 new races to which the Heil Hanna 3 variety was resistant. Honecker (5, 6) classified 9 races in Germany; however, he used as differentials German varieties rather than the 6 varieties used by other investigators.

Wolff (19), in 1874, made successful inoculations of species of *Triticum* with ascospores obtained from cleistothecia formed on those species. Both Marchal (11) and Salmon (16) carried out infection studies using ascospores from cleistothecia on *H. vulgare*. With these ascospores they infected *H. vulgare* and other species of *Hordeum* but not *Triticum aestivum* L., *Avena sativa* L., or *Secale cereale* L. They concluded that the infective ability of the ascospore was similar to that of the conidium.

This study was undertaken to determine the pathogenic variability of *E. graminis* f. sp. *hordei* in North America. The distribution of the races in both United States and Canada was determined, since the survey of races of the organism in Canada had been discontinued. A review of the previous work on the identification of physiological races is presented to aid in the interpretation of the results from this study. Since cultures derived from ascospores were used, reference is made to the results obtained by other workers in the use of ascospores.

MATERIALS AND METHODS.—In this study, the 6 varieties used by Cherewick (1) were employed to differentiate physiological races of *E. graminis* f. sp. *hordei*. This made possible the comparison of new races found in this investigation with those reported by previous workers.

The cultures were obtained from diseased plants either collected by the author or sent to him from various places in North America. When infected plants were received, they were transplanted to pots and placed in isolation in cages in the greenhouse. The conidia formed on these plants were used to inoculate seedlings growing in 300×25-mm tubes. When leaves with cleistothecia were received, they were stored in envelopes in a refrigerator at 12°C.

The cultures were maintained on seedlings of the Heil Hanna 3 (C. I. 682) or the Manchuria (C. I. 2330) varieties. Seedlings of these varieties were grown either in 300×25-mm test tubes or in 3- or 4-in. clay pots under lamp chimneys plugged with cotton. The seedlings in the test tubes were stored in a refrigerator at a temperature of 12°C equipped with a 15-watt daylight fluorescent tube. The cultures in the tubes were transferred every 4–6 weeks. The cultures on plants in clay pots under lamp chimneys were grown for only short periods of time; this was primarily for the purpose of increasing inoculum. Methods of obtaining and maintaining cultures from ascospores formed in cleistothecia will be discussed in detail in another paper.

The method used to inoculate the differential varieties was similar to that used by other investigators. Eight to 10 seeds of each variety were planted in 3-in. clay pots. Seedlings were inoculated in the first- or second-leaf stage by shaking conidia from infected plants on them. Although the time of day was not an important factor for obtaining infection, inoculations were usually made in the late afternoon because it was easier to control the temperature in the greenhouse during the night than during the day. Following inoculation, the seedlings were placed in isolation cages on greenhouse benches where the temperature was maintained at approximately 20°C. Readings were made 7–10 days following the inoculation.

Many of the original cultures, especially those obtained from ascospores, contained more than 1 race. Races obtained from these cultures were purified by making several single pustule isolations from the differential varieties of Newton and Cherewick (14). Final identification was made on each culture only after several single pustule isolations had been made and the reaction on each differential variety was distinct.

RESULTS.—During the years 1950–1954, 6 new races, as well as 9 races previously reported in North America, were isolated. The new races were distinct from those reported in Argentina (3, 17) and Japan (4). The reactions of the 6 differential varieties to 19 races isolated in North America, 3 in Japan, and 2 in Argentina are given in Table 1. The data on the first 12 races are similar to those reported by Newton and Cherewick (14), and data on race 13 agree with those of Jensen (7). The information on races 14–19 was obtained in these studies. The reactions to the 3 races found in Japan were reported by Hiura and Heta (4), and reactions to the 2 races in Argentina were reported by Favret and co-workers (3, 17).

The method by which the 24 races in Table 1 are distinguished from each other is shown in the analytical key. In order to separate race 5 from those in Argentina, the Duplex (C.I. 2433) variety was included. The reaction of the Chevron variety to race 5 was never determined; however, it is possible that

TABLE 1.—*Mean infection type produced on seedling leaves of 6 differential varieties of barley by 24 physiological races of Erysiphe graminis f. sp. hordei*

Physiologic race[b]	Mean infection type[a] on variety: Black Hulless	Chevron	Goldfoil	Heil Hanna 3	Nepal	Peruvian
1[c]	0-2	0	0	1-2	1-2	0-1
2	1-2	0	0	4	4	1
3	3-4	0-1	0	4	4	3-4
4	4	0	0	3-4	4	1
5[c]	3	–	4	4	4	4
6	0-2	0-1	0	3-4	0-1	0-1
7[c]	0-1	0	3-4	3-4	0-1	0-1
8	3	3-4	0	3-4	3-4	0-1
9	1-2	4	0	4	1-2	0-1
10	1-2	0-1	0	4	1-2	3
11	4	4	0	4	4	4
12[c]	1	3	4	4	1-2	1
13	2	1	4	4	4	1-2
14	1-2	4	0	4	3-4	1-2
15	1-2	1	0	4	3-4	4
16	1	3-4	0	4	2	3-4
17	1	4	0	4	4	4
18	1-2	0-1	4	4	0	3-4
19	3-4	4	0	4	2	2
Jap. 13[c]	4	2-3	0	0	4	1
Jap. 14[c]	4	2-3	2-4	0	4	1
Jap. 15[c]	4	2-4	0	0	4	1
Arg. 1[c]	4	4	4	4	4	4
Arg. 2[c]	4	4	4	4	4-4	4

[a] Mean infection type: 0 = immune, no visible signs of infection; 1 = highly resistant, a slight development of mycelium; 2 = moderately resistant, moderate development of mycelium with a slight production of conidia, necrosis but little chlorosis; 3 = moderately susceptible, moderate to abundant development of mycelium accompanied by moderate sporulation, little necrosis, some chlorosis; 4 = highly susceptible, large pustules, abundant sporulation, no necrosis.

[b] Jap. refers to races isolated in Japan and Arg. to races isolated in Argentina. All others were isolated in North America.

[c] Races not isolated in this study.

race 5 and the Argentina races could be separated by the reaction of that variety. The 2 Argentina races are differentiated by the Anoidium (C.I. 7269) variety. Japanese races 13 and 15 differ in their reaction on the Colsess variety.

ANALYTICAL KEY FOR THE IDENTIFICATION OF 24 PHYSIOLOGICAL RACES OF ERYSIPHE GRAMINIS F. SP. HORDEI ON THE BASIS OF THEIR PATHOGENICITY ON 9 DIFFERENTIAL VARIETIES OF BARLEY.

A. Black Hulless susceptible
  B. Peruvian susceptible
    C. Goldfoil susceptible
      D. Duplex susceptible
        E. Anoidium susceptible — Arg. 2
        EE. Anoidium resistant — Arg. 1
      DD. Duplex resistant — 5
    CC. Goldfoil resistant
      D. Chevron susceptible — 11
      DD. Chrevon resistant — 3
  BB. Peruvian resistant
    C. Heil Hanna 3 susceptible
      D. Chevron susceptible
        E. Nepal susceptible — 8
        EE. Nepal resistant — 19
      DD. Chevron resistant — 4
    CC. Heil Hanna 3 resistant
      D. Goldfoil susceptible — Jap. 14
      DD. Goldfoil resistant
        E. Colsess susceptible — Jap. 15
        EE. Colsess resistant — Jap. 13
AA. Black Hulless resistant
  B. Peruvian susceptible
    C. Goldfoil susceptible — 18
    CC. Goldfoil resistant
      D. Chevron susceptible
        E. Nepal susceptible — 17
        EE. Nepal resistant — 16
      DD. Chevron resistant
        E. Nepal susceptible — 15
        EE. Nepal resistant — 10
  BB. Peruvian resistant
    C. Chevron susceptible
      D. Goldfoil susceptible — 12
      DD. Goldfoil resistant
        E. Nepal susceptible — 14
        EE. Nepal resistant — 9
    CC. Chevron resistant
      D. Goldfoil susceptible
        E. Nepal susceptible — 13
        EE. Nepal resistant — 7
      DD. Goldfoil resistant
        E. Nepal susceptible — 2
        EE. Nepal resistant
          F. Heil Hanna 3 susceptible — 6
          FF. Heil Hanna 3 resistant — 1

The 6 new races are pathogenic on the Heil Hanna 3 variety, but can be separated by the reactions of the other 5 varieties. The Goldfoil variety was only susceptible to race 18, which was isolated in California. The Black Hulless variety was only susceptible to race 19, isolated from plants grown in Arkansas. The other 4 new races can be differentiated on the basis that Peruvian is resistant to race 14, Chevron to race 15, Nepal to race 16, and all 3 of these varieties are susceptible to race 17. The 6 new races can be dis-

TABLE 2.—*Physiological races of the powdery mildew fungus isolated from conidia on barley plants grown at various locations in the United States, 1950–1953*

Year	Location	Physiological race: 2	3	4	6	9	13	14	15	16	18	Total
1950	California		1									1
	Florida					1						1
	Georgia					1						1
	Maryland					1						1
	Mississippi					2						2
	North Carolina					1						1
	South Carolina				1	2						3
	Texas			2								2
	Virginia					2						2
1951	Mississippi				1	1						2
	North Carolina				1	5			1			7
1952	California						1					1
	North Carolina				1	7						8
	Tennessee					1						1
	Virginia	1			2	3		1		1		8
1953	California										1	1
	Georgia				2	2						4
	Mississippi					1						1
	North Carolina					2						2
Total and grand total		1	1	2	8	32	1	1	1	1	1	49

TABLE 3.—*Physiological races of the powdery mildew fungus isolated from cleistothecia on barley plants grown at various locations in North America from 1950 to 1954*

Year	Location	Physiological race													
		2	3	4	6	8	9	10	11	14	15	16	17	19	Total
1950	Arkansas	3		1			2			1			1	1	9
	Florida						1								1
	Georgia				1		2								3
	Maryland						4								4
	North Carolina						5								5
	New York					1				1					2
	Oklahoma				1		1								2
	South Carolina				1		4								5
	Texas			1				2							3
	Wisconsin				1		1								2
	British Columbia, Canad.		2								3				5
	Ontario, Canad.		1			1	1		1	1		2			7
1951	North Carolina				1		3								4
	Wisconsin					1	5		1	4					11
	British Columbia, Canad.		1												1
	Ontario, Canad.			1		8	2		1				1		13
1952	North Carolina				1		1								2
	Oklahoma							1							1
	British Columbia, Canad.		9												9
1953	New York					3									3
	North Carolina						5								5
	Texas			1											1
1954	Georgia					1				1					2
	Kentucky						2								2
	Michigan			1		1								1	3
	Mississippi			2			5								7
	Nebraska			1	1		2								4
	New York					3			2						5
	North Carolina				1		4								5
	North Dakota						1								1
	Pennsylvania					2			1						3
	Tennessee				1		3								4
	Texas	1								1					2
	Utah		2												2
	Virginia					1	3					2	1	1	8
	Wisconsin			1			1								2
	Ontario, Canad.					1						1	1		3
	Total and grand total	4	15	9	9	23	58	3	6	9	3	5	4	3	151

tinguished from those found in Japan, since the new races are pathogenic on Heil Hanna 3 and those from Japan are not. All of the new races, with the exception of 18, can be distinguished from those found in Argentina by the reaction of the Goldfoil variety. The Chevron variety is resistant to race 18 but not to the races from Argentina.

The distribution of the races of the powdery mildew fungus isolated from conidia on infected plants grown at various locations throughout the United States is given in Table 2. Most of the cultures were obtained from plants grown in southeastern United States where races 9 and 6 are most prevalent. Races 3, 13, and 18 were isolated by C. W. Schaller from plants grown in California. The following races were obtained from only 1 state: Race 4 from Texas, races 14 and 16 from Virginia, and race 15 from North Carolina.

The races of the powdery mildew fungus derived from cleistothecia on leaves of plants grown at various locations in North America are given in Table 3. Most of the cultures were obtained from dried leaf material, but occasionally cleistothecia were present on plants that had viable conidia. The most prevalent race from British Columbia, Canada, was race 3, which was isolated 13 times. Race 15 was isolated 3 times from this area. Race 8 was most frequently found in material from Ontario, Canada, and from Wisconsin, New York, and Pennsylvania, with races 11 and 14 being isolated occasionally. As was the case with the conidial material, race 9 was isolated most frequently from southeastern United States.

DISCUSSION.—Although the varieties Duplex (C. I. 2433), Kwan (C. I. 1016), Hanna (C. I. 906), and others were included in many of the tests, only the results obtained with the 6 varieties used by Cherewick (1) are included. As would be expected, the number of races that could be identified was increased with the use of additional differential varieties. Since it is not possible to determine whether these are new

races or races that could have been identified by the earlier workers had they used the additional varieties, they are not included in this report.

The 2 biotypes of race 8, based on the susceptibility of the Duplex variety found by Hiura and Heta (4), are not uncommon in North America. This variety is known to have 3 genes that control resistance to the race 3 found in California. During this study, the Duplex variety gave reactions to cultures of race 8 ranging from 0 to 3–4.

The infective range of ascospores in cross-inoculation studies was reported by early workers to be similar to that of conidia. Cherewick (1) was able to obtain as many as 4 races of the powdery mildew fungus from ascospores in the same field where he was able to isolate only 2 races from conidia. Only at Blacksburg, Virginia, were more than 2 races found in a conidial collection, but at several locations more than 2 races were obtained from ascospores on a single variety.

More than 1 race of *E. graminis* f. sp. *hordei* can be isolated from a single cleistothecium (15). By using cultures obtained from ascospores, it may be possible to obtain races of the organism not previously reported.

Several varieties have been found to be resistant to all North American races of the organism to which they have been tested (8, 9, 12, 14, 18). Twelve genes have been identified that control resistance to the race 3 found in California (12). Preliminary studies with varieties that are known to have only 1 gene controlling resistance to the race 3 from California indicate that resistance to other races may be controlled by the same genes or a block of genes closely linked with them.

Studies are now in progress to select individual host genes for resistance to use in determining the pathogenic variation in *E. graminis* f. sp. *hordei*. The 6 differential varieties now used have been found to be inadequate for determining the pathogenic variation for use in breeding for disease resistance in the United States, Germany, and other countries. For a set of differential varieties to be satisfactory in all countries, the number of varieties would have to be increased. This would not only increase the number of races that could be identified, but it would be impossible to determine if they are new races or races undetected by the differential varieties used by earlier workers. There is evidence, from cleistothecal collections made in the field and from studies with ascospores from single cleistothecia, that new races are formed during the sexual phase of the life cycle of the organism. Varieties of barley are known that are resistant to more than 1 race, and preliminary studies indicate that their resistance is governed by 1 gene or a group of closely linked genes. The use of individual genes in the host for determining pathogenic variation in *E. graminis* f. sp. *hordei* would not only be helpful in breeding programs for disease resistance, but it would make possible detailed genetic studies of the host and the pathogen.

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WESTERN ASTER YELLOWS VIRUS INFECTION OF SQUASH, PUMPKIN, AND CUCUMBER [1]

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SUMMARY

Symptoms of aster yellows virus infection on squash, pumpkin, and cucumber plants consisted of vein clearing, yellowing, and stunting. When cucumber plants became infected following experimental inoculation, they wilted and died. Naturally infected squash and pumpkin plants were characterized by the proliferation of numerous secondary shoots and green malformed flowers.

Plants of 5 species of Cucurbitaceae became infected with aster yellows virus following the feeding of infective aster leafhoppers, *Macrosteles fascifrons* (Stal). These were of the following species and varieties: *Cucurbita pepo* L., var. Yellow Crookneck squash and Early White Bush Scallop squash; *C. moschata* Duch., var. Kentucky Field pumpkin; *C. mixta* Pang., var. Green Striped Cushaw pumpkin; *C. maxima* Duch., var. Warted Hubbard squash; and *Cucumis sativus* L., var. National Pickling and Early White Spine cucumber.

Aster yellows virus was transmitted from naturally infected squash and pumpkin plants by the aster leafhopper to plantain test plants and from naturally infected squash by the leafhopper *Colladonus montanus* (Van Duzee) to celery test plants. The virus was identified on the basis of the symptoms that developed on plantain, celery, and aster test plants. The virus was transmitted by grafting from naturally infected squash plants to healthy squash plants. Leafhoppers of the species *Colladonus montanus* (Van Duzee) collected in a squash field were found to be naturally infective with respect to aster yellows virus.

Symptoms of infection by aster yellows virus have been observed on squash and pumpkin in the Sacramento valley of California for the past 3 years (1953–1955). During the summer of 1954, almost all plants in one 20-acre field of Yellow Crookneck squash, which were being grown for seed near Grimes, Colusa County, were infected with aster yellows virus. During the same year, about 20 per cent of the plants in a pumpkin field near Yuba City in Sutter County were infected.

Kunkel (7) demonstrated that the aster yellows virus has a wide host range and reported more than 170 species in 38 different families of plants as susceptible to the virus. Severin and Frazier (8) reported natural infection in 14 species of vegetables in 6 plant families. Köhler and Klinkowski (6, p. 683-689) list 270 species of plants in 39 families as hosts of aster yellows virus. Their inclusion of *Cucurbita maxima* Duch. and *C. pepo* L. as hosts apparently is based on the observations of plant disease survey workers.

Cassells (1, 2, 3) observed symptoms resembling those caused by aster yellows on summer squash plants in New England.

MacLeod, according to Conners and Saville (4, p. 70; 5, p. 78), reported squash and pumpkin plants with symptoms resembling those caused by aster yellows virus at Fredericton, New Brunswick, Canada. He graft-transmitted a virus to healthy squash and pumpkin plants but failed to transmit it to cucumber and melon plants (4, p. 70). He suggested a strain of aster yellows virus as the cause of the disease. There appear to be no published reports of any experimental work demonstrating the experimental or natural transmission by leafhoppers of aster yellows virus to any species of Cucurbitaceae.

The present paper is concerned with the experimental transmission to squash, pumpkin, and cucumber plants of aster yellows virus by the aster (6-spotted) leafhopper, *Macrosteles fascifrons* (Stal). The virus was acquired by leafhoppers from both naturally infected cucurbits and from cucurbits that had become infected following experimental inoculation, and it was transmitted to test plants of species on which symptoms of the virus could be positively identified. The symptoms caused by aster yellows virus on field- and greenhouse-grown cucurbits are described. The virus was graft-transmitted from diseased to healthy squash plants.

MATERIALS AND METHODS.—The squash, pumpkin, and cucumber plants were grown from seeds in 4-in. clay pots and inoculated with aster yellows virus soon after the first 2 leaves had developed. The plants were enclosed in a cylindrical cage 8 in. in diameter and 12 in. in height. The cage consisted of a cloth-covered wooden frame and had a glass front.

The infective aster leafhoppers, *Macrosteles fascifrons* (Stal), were reared on infected common plantain, *Plantago major* L. The aster yellows virus was a western strain of the virus that has been maintained in the greenhouse at Berkeley for more than 20 years. The noninfective aster leafhoppers were reared on Sacramento barley, which is immune from the virus. Male leafhoppers were used in all tests to avoid egg deposition in the inoculated plants. Transfer of leafhoppers was accomplished by use of an aspirator.

Common plantain, celery, and aster test plants were grown from seed and transplanted to 4-in. clay pots. The test plants were usually in the 4- to 6-leaf stage when exposed to leafhoppers.

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It was usually not possible to transplant the large field-grown naturally infected squash and pumpkin plants to clay pots. Infected shoots were cut off, wrapped in moist newspapers, and brought to the greenhouse. The shoots were then caged with the cut stems extending into a jar of water. Noninfective leafhoppers were fed on these green shoots for a period of 2 days or more.

INFECTION OF CUCURBITS FOLLOWING EXPERIMENTAL INOCULATION WITH ASTER YELLOWS VIRUS.—Greenhouse-grown plants of 5 species of cucurbits became infected with aster yellows virus after they had been fed upon by 10–25 infective aster leafhoppers for several days. Symptoms developed in inoculated plants of the following varieties and species: *Cucurbita pepo* L., var. Table Queen squash (10 infected of 10 inoculated), Yellow Crookneck squash (18 of 24), Early White Bush Scallop squash (24 of 36); *C. moschata* Duch., var. Kentucky Field pumpkin (5 of 10); *C. mixta* Pang., var. Green Striped Cushaw pumpkin (17 of 22); *C. maxima* Duch., var. Warted Hubbard squash (4 of 10); *Cucumis sativus* L., var. National Pickling cucumber (15 of 30); Early White Spine cucumber (3 of 12). None of 20 inoculated plants of *Cucumis melo* L., var. Persian melon, developed symptoms.

SYMPTOMS ON EXPERIMENTALLY INOCULATED PLANTS.—Twelve to 14 days after inoculation, Early White Bush Scallop and Yellow Crookneck squash plants developed prominent vein clearing that was followed by vein yellowing and downward cupping of the leaves. The plants became chlorotic and stunted, and young leaves were severely dwarfed. Secondary shoots, which developed in the axils of the leaves, had shortened internodes and bore stunted chlorotic leaves. These squash plants did not produce as many secondary shoots as naturally infected field plants, however, and consequently never developed a witches'-broom appearance. The secondary shoots were also more severely stunted than those on naturally infected plants. The leaves on infected plants were somewhat thickened and had swollen and raised veins. The stems developed dark green, raised, ribbed areas.

Pumpkin plants developed vein clearing, yellowing, stunting, and either upward or downward cupping of the younger leaves. Secondary shoots developed from leaf axils, and interveinal yellowing of leaves was noted on some infected pumpkins.

Infected cucumber plants became stunted and chlorotic and developed dwarfed terminal leaves. The intermediate leaves were yellow, and they rolled upward at the margins. The infected cucumber plants usually wilted and died within 5–10 days after the first symptoms appeared.

The symptoms produced on inoculated cucumber plants in the greenhouse are similar to those observed in the field in areas where aster yellows virus has been a problem on other host plants. Cucumber plants in the field have been observed to become yellow, to wilt, and to die. The scattered distribution of infected plants in the field is like that expected for a virus disease; however, limited attempts to recover aster yellows virus from such field cucumbers have not been successful. During the summer of 1953, a grower in the Sacramento valley reported the total failure of a cucumber planting. According to the grower, the plants wilted and died. This field of cucumbers was located only a short distance from the field of squash, previously mentioned, that suffered almost 100 per cent loss during the following year. It would appear that aster yellows virus may have been responsible for the failure of the cucumber crop.

SYMPTOMS ON NATURALLY INFECTED SQUASH AND PUMPKIN PLANTS.—Naturally infected squash plants were chlorotic and dwarfed, and many secondary shoots developed from the axils of the leaves. In addition, numerous shoots arose from the axils of leaves on the secondary shoots, and this gave the squash plants a bushy or witches'-broom appearance (Fig. 1, A). Some of the younger leaves showed vein clearing, and most were dwarfed, yellow, and misshapen. Many were borne on elongated petioles. The leaves usually were stiffened, rigid, and somewhat thickened, with enlarged midribs and lateral veins. Infected plants were easily detected in the field because of the conspicuous yellowing and dwarfing of the young leaves and the rigid, erect habit of the terminal shoots. The flowers were malformed and green, often with leafy bracts, and were borne on abnormally elongated peduncles (Fig. 1, A). Diseased squash plants bore small malformed fruits that were lighter than normal in color and contained thin seeds that were not viable.

Pumpkin plants naturally infected with aster yellows showed yellowed older leaves with various degrees of marginal burning; in extreme cases, the entire leaves became dry. Secondary shoots with shortened internodes and stunted yellow leaves developed from the axils of the leaves (Fig. 1, B). Few or no fruits developed on infected plants.

LEAFHOPPER TRANSMISSION OF ASTER YELLOWS VIRUS FROM NATURALLY INFECTED PLANTS TO TEST PLANTS.—Noninfective aster leafhoppers were fed for 2–4 days on field-grown squash plants suspected of being infected with aster yellows virus. The insects were then transferred, for a period of 1 month each, to 2 successive healthy plants of common plantain, *Plantago major* L. The leafhoppers acquired virus from 3 of 6 naturally infected Yellow Crookneck squash shoots on which they were fed and infected 8 of 12 plantain test plants. The virus was transmitted from naturally infected pumpkin in 1 of 2 tests. The aster leafhopper acquired virus from 2 of 3 Yellow Crookneck squash plants that developed symptoms following experimental inoculation, and these leafhoppers transmitted the virus to 3 of 6 plantains. The leafhopper *Colladonus montanus* (Van Duzee) acquired virus from 2 of 4 naturally infected squash plants and transmitted it to 3 of 12 celery plants. Noninfective aster leafhoppers acquired virus from diseased plantains that

FIG. 1. Terminal shoots of plants naturally infected with western aster yellows virus. A) Yellow Crookneck squash showing green malformed flowers and numerous secondary shoots resulting in a witches'-broom effect. B) Pumpkin showing secondary shoots and chlorotic rolled leaves.

had become infected following inoculation with virus from naturally infected squash plants. They transmitted virus to 4 of 4 asters tested. All infected plantain, celery, and aster plants developed symptoms typical of those caused by aster yellows virus.

GRAFT TRANSMISSION OF ASTER YELLOWS VIRUS FROM NATURALLY INFECTED SQUASH.—Aster yellows virus was transmitted by grafting from naturally infected Yellow Crookneck squash plants to healthy Early White Bush Scallop squash plants. A wedge-shaped piece of tissue was removed from the leaf axil of a healthy squash plant, and a wedge of tissue from a lateral or terminal shoot taken from a naturally infected squash plant was promptly inserted into the cut. The graft was then wrapped with string. In the first test, 3 of 6 plants developed vein clearing, yellowing, stunting, and secondary shoots. In a second test, 6 of 6 grafted plants developed symptoms typical of those caused by aster yellows virus. The incubation period varied from 28 to 54 days.

LEAFHOPPER VECTOR RESPONSIBLE FOR FIELD TRANSMISSION OF ASTER YELLOWS VIRUS TO SQUASH.—An attempt was made to determine the natural leafhopper vector of aster yellows virus in the Sacramento Valley squash field in which almost all of the plants were infected. In September, 1954, 500 sweeps with an insect net resulted in the capture of only 3 specimens of *Colladonus montanus* (Van Duzee) in this field. Four additional specimens were collected in an adjacent cantaloupe field. No specimens of *Macrosteles fascifrons* (Stal) were found. A much higher population of one or both of these leafhopper species must have been present earlier in the spring or summer to account for the high incidence of disease in this field.

The 7 specimens of *C. montanus* collected in the squash and cantaloupe fields were transferred to successive healthy squash plants at 2- to 4-day intervals to determine if they were naturally infective. Three of 7 squash plants on which the leafhoppers fed developed symptoms identical to those caused by aster yellows virus.

DISCUSSION.—The high incidence of the disease on cucurbits prompted the study of the cause. The explanation for this high incidence and apparent sudden appearance of aster yellows virus on cucurbits and certain other host plants not previously recognized to be host of the virus is not known. Perhaps a new strain of virus has developed; however, the virus recovered from naturally infected cucurbits does not appear to differ from western aster yellows virus as known for over 25 years in California. The most likely explanation is that during previous years environ-

mental conditions resulted in such a low incidence of the disease that it has been unnoticed. During the past 3 years the high incidence might possibly be explained by environmental conditions favorable to high leafhopper populations, although no data were collected on insect numbers during the years in question.

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THE INFLUENCE OF CERTAIN PLANT NUTRIENTS ON INFECTION OF SOYBEANS BY RHIZOCTONIA SOLANI [1]

J. J. Castano and M. F. Kernkamp [2]

SUMMARY

Soybeans were inoculated with *Rhizoctonia solani* and grown in sand culture with deficiencies of calcium, magnesium, iron, sulfur, nitrogen, phosphorus, or potassium. A deficiency of any of these elements except potassium increased the severity of infection. In tests under other than deficiency conditions, the degree of infection was not influenced by the different levels of calcium and magnesium used. The cortical tissues of calcium-deficient plants were poorly organized, with thin cell walls, poorly developed middle lamellae, and large intercellular spaces. This condition apparently allowed easy penetration and invasion by hyphae of the pathogen.

Field observations[3] suggested that deficiencies of certain mineral elements in some Minnesota soils predispose soybeans to infection by *Rhizoctonia solani* Kühn. According to data furnished by Kernkamp et al[3] and by Khan[4], deficiencies of calcium and magnesium in nutriculture of soybeans in the greenhouse made them more susceptible to attack by *R. solani*. Deficiencies of calcium and magnesium were associated with poor development of cell walls and middle lamellae in the cortical tissues of soybean roots and stems, and this allowed easier penetration and ramification of hyphae of *R. solani* in those tissues. Khan[4], however, made no tests on the effects of different levels of these minerals, but studied only their complete absence from the nutrient solutions. It was desirable, therefore, to determine if Khan's preliminary results could be corroborated and if different levels of the 2 minerals would influence the infection of soybeans by *R. solani*. With this knowledge, presumably proper applications of calcium and magnesium could be recommended as an aid in the control of root rot under certain circumstances.

In addition, tests were made on the influence of iron, nitrogen, phosphorus, sulfur, and potassium on the degree of infection of soybeans by *R. solani*.

Materials and methods.—Sach's normal solution with the following composition was used in the tests: $CaSO_4 \cdot 4H_2O$, 0.25 g; $CaH_4(PO_4)_2 \cdot H_2O$, 0.25 g; $MgSO_4 \cdot 7H_2O$, 0.25 g; NaCl, 0.08 g; KNO_3, 0.70 g; $FeCl_3 \cdot 6H_2O$, 0.005 g; water, 1000 ml. The solutions were prepared with double-distilled water and C.P. grade chemicals.

Tests with nutrients were made in glazed crocks containing new white sand that had been treated with

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[3] Kernkamp, M. F., D. J. deZeeuw, S. M. Chen, B. C. Ortega, C. T. Tsiang, and A. M. Khan. 1952. Investigations on physiologic specialization and parasitism of Rhizoctonia solani. Minn. Agr. Exp. Sta. Bul. 200, 36 p.

[4] Khan, A. M. 1950. Factors affecting the pathogenicity of Rhizoctonia solani on legumes. Ph.D. Thesis. University of Minnesota.

hydrochloric acid and washed in distilled water. The nutrient solutions were prepared so that calcium, iron, nitrogen, phosphorus, sulfur, magnesium, or potassium was absent from each treatment, and the complete solution served as a check. The solutions were applied to the crocks by the "slop culture" method.[5]

The variety Ottawa Mandarin soybeans was used throughout the studies, and 25 seeds were planted in each crock. Ottawa Mandarin was selected because it is somewhat more resistant to Rhizoctonia than some others, and it was anticipated that there would be more differentiation among treatments than there would be with a more susceptible variety.

Two races of *R. solani*, IB4 and CT1C, were used. A race, as used here, is a culture that originated from a hyphal tip and was known from previous studies to differ culturally and pathogenically from other cultures of similar origin. Both of these races were originally isolated from field grown soybeans.

The inoculum was prepared by growing the 2 races separately in potato-dextrose broth in 250-ml Erlenmeyer flasks. The fungus mats were chopped with a Waring Blendor, and 100 ml of aqueous suspension of mycelium was added to each crock. The 9 treatments used with each race are indicated in Table 1. Each treatment, which was replicated 3 times, consisted of 1 glazed crock with 25 soybean seeds treated with 1 of the nutrient solutions (Table 1). There were 9 treatments, and the experiment was made twice; therefore, there were 18 crocks in each replicate.

The tests were made in a greenhouse operating at 27°C ± 5. After 3 weeks the plants were removed from the sand, and notes were recorded on the percentages of dead and infected plants in each treatment.

EXPERIMENTAL RESULTS.—The composition of the nutrient solutions used in the tests and the percentages of dead and infected plants in each treatment for the 2 races of *R. solani* are given in Table 1. The effects of these treatments on soybeans are illustrated in Figure 1. It is obvious that race IB4 was much more virulent than CT1C. Also, it is obvious that deficiencies of the various nutrients influenced the degree of infection of soybeans by the races of *R. solani*.

The results with deficiencies of calcium and magnesium agree with those reported by Khan,[4] although the general level of infection was not so great. Khan used a different race and reported the following: 27.5, 68.0, and 42.5 per cent dead plants, respectively, with the check, calcium deficient solution, and magnesium deficient solution. The data in Table 1 are in relative proportion to the data presented by Khan.

To determine if different levels of calcium and magnesium would have the same general effect as deficiencies, solutions containing 0.001, 0.002, 0.003, and 0.004 M solutions of calcium and magnesium were supplied to soybeans inoculated with race IB4 of *R. solani*. In these tests, the degree of infection of plants grown at the lowest level of the 2 minerals did not differ significantly from that of plants grown at the highest levels. It was concluded that even slight amounts of the nutrients were adequate for the plants to carry on normal processes and to ward off attacks by *R. solani*.

TABLE 1.—*Average percentages of dead and infected plants induced by 2 races of Rhizoctonia solani on soybeans grown in nutrient solutions deficient in certain elements*

Treatments[a]	Percentage of dead and infected plants[b]			
	Race IB4		Race CT1C	
	Dead plants	Infected plants	Dead plants	Infected plants
Plants not inoculated				
Complete nutrients	0.0	0.0	0.0	0.0
Plants inoculated				
Complete nutrients	2.7	48.0	1.3	12.0
Minus Ca	12.0	86.7	11.3	36.0
Minus Fe	14.7	83.7	1.3	38.7
Minus N	6.7	72.7	1.3	16.7
Minus P	7.3	68.0	0.0	17.3
Minus S	10.0	62.7	0.0	16.0
Minus Mg	5.3	60.0	0.0	16.7
Minus K	4.7	50.7	0.0	13.3

[a] Each treatment consisted of 1 glazed crock containing 25 soybean seeds and treated with 1 nutrient solution.
[b] Average of 2 tests with 3 replicates for each treatment.

The plants grown with calcium-deficient nutrients had a poor root system, very soft tissues, and slightly smaller leaves. The cortical cells of calcium-deficient plants were thin, and there were large intercellular spaces. The middle lamella was difficult to distinguish, and in some cells it was disintegrated, apparently because of the lack of calcium. These results corroborate those reported by Kernkamp et al[3] and support the theory that the cortical tissue of calcium-deficient plants is poorly constructed, allowing for easier penetration and invasion by hyphae of *R. solani*.

Deficiencies of iron, nitrogen, phosphorus, and sulfur also had a marked influence on infection of plants by race IB4. Some differences were apparent in experiments with race CT1C; however, the latter was weakly pathogenic, and the differences were very slight, although the trend was the same.

DISCUSSION.—The deficiency of nitrogen in relation to root rot might have some significance. In these tests, nitrogen deficiency was associated with a high degree of infection. In other tests made by the junior author, it has been observed frequently that nodulation is very poor or lacking when soybean plants are affected with root rot. Thus the implication is that plants grown in soils deficient in nitrogen, or plants deficient of nodulation, may be predisposed to infection by *R. solani*.

The relationship between iron deficiency and infection by *R. solani* may be of great significance from a practical standpoint in Minnesota. It is well known that soybeans suffer from iron chlorosis in many parts of the soybean-growing area of this state. The junior author and his associates frequently have

[5] Bonner, J. and A. W. Galston. 1952. Principles of plant physiology. W. H. Freeman and Co., San Francisco. 499 p.

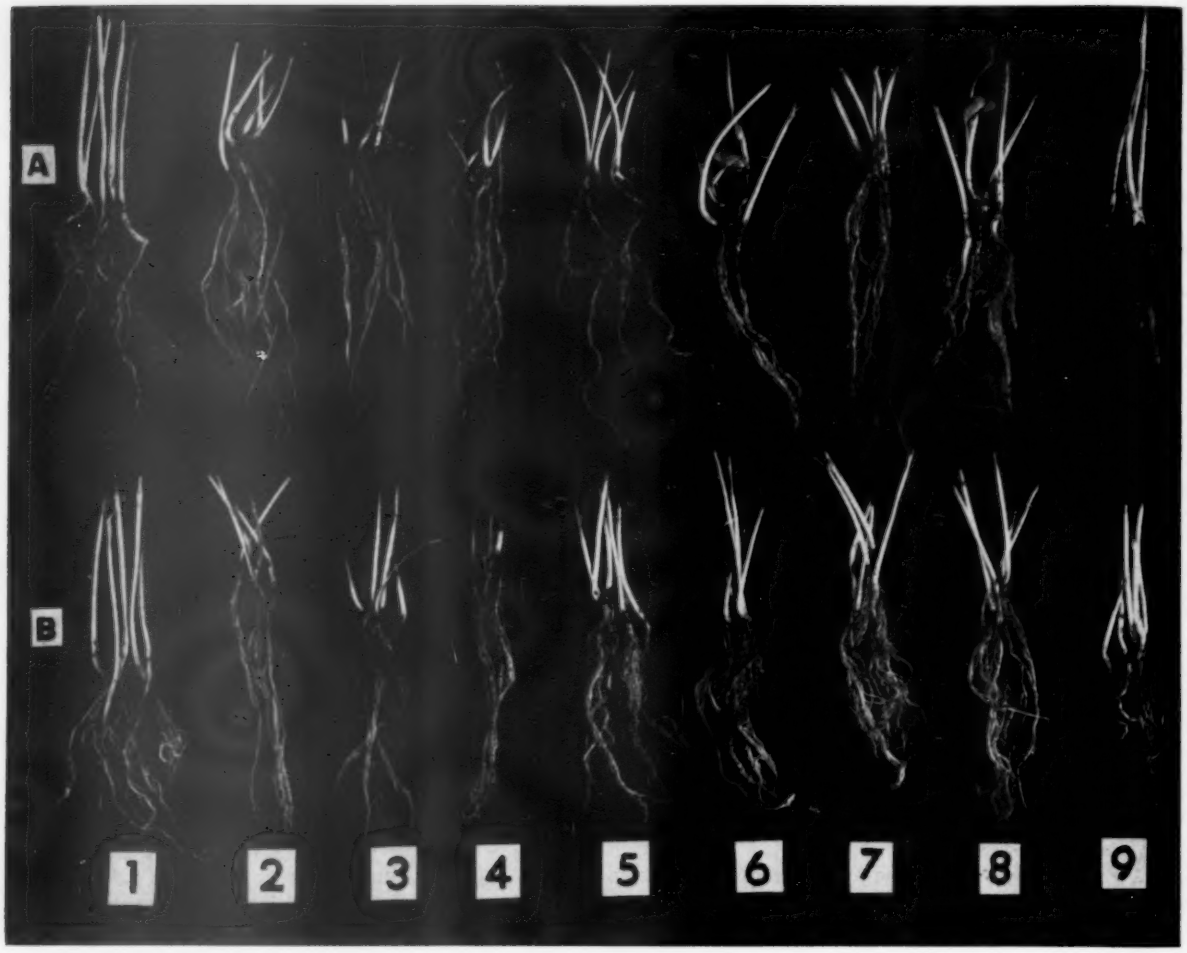

FIG. 1. Effect of nutrient deficiencies on infection of soybeans by 2 races of *Rhizoctonia solani*. A) Race IB4. B) Race CT1C. 1) Control (without inoculum) plus complete nutrients. 2) Inoculated, plus complete nutrients. 3) Inoculated, minus calcium. 4) Inoculated, minus iron. 5) Inoculated, minus nitrogen. 6) Inoculated, minus phosphorus. 7) Inoculated, minus sulfur. 8) Inoculated, minus magnesium. 9) Inoculated, minus potassium.

observed that root rot is severe in patches of soybeans that also have typical symptoms of iron chlorosis. Thus it is possible that injury from root rot might be alleviated to some extent by the proper application of iron to soybean fields. According to Bennett[6] and King, Tveit, and Baskin[7], these deficiencies can be corrected by spraying leaves of plants with ferrous sulfate.

[6] Bennett, J. P. 1931. The treatment of lime-induced chlorosis with iron salts. Calif. Agr. Exp. Sta. Cir. 321, 12 p.

[7] King, T. H., M. Tveit, and A. D. Baskin. 1950. Sprays to control chlorosis in flax and strawberries grown on alkaline soil in Minnesota. (Abs.) Phytopathology 40: 14-15.

Deficiency of sulfur may or may not be of practical importance in Minnesota, although it did predispose plants to infection in these tests.

Potassium deficiencies did not appear to be significant in these studies. Infection was limited to a few small lesions whose edges healed promptly. In most cases the lesions did not girdle the stems. In general the results with potassium-deficient nutrients were very similar to those of the inoculated checks.

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AN INEXPENSIVE MULTIPURPOSE SOIL STEAMER[1]

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SUMMARY

A small, inexpensive, multipurpose unit for steaming soil has been developed. It consists of a wooden box that can hold 21 cu. ft. of bulk soil, 16 flats of soil, or 150–1000 empty clay pots. A grid of pipes with regularly placed orifices is so located in the box that no particle of soil is more than 6 in. from steam sources. The attainment of 212°F is, therefore, rapid and uniform. With a steam flow rate of about 175 lb./hour (5 delivered boiler horsepower), this level is reached by moderately moist soil in approximately 30 minutes. This temperature can then be easily maintained for the requisite half hour. Units of this type have been extensively and satisfactorily used over a 7-year period to free soil of a wide range of fungi, bacteria, nematodes, and viruses.

The search for a small inexpensive unit for steam treatment of soil has led through many modifications to the present design. The equipment here described can be used for bulk soil, flats with or without soil, or empty pots or cans 7 in. or less in diameter. It can be set in a permanent location, or if portability is desirable it can be mounted on wheels (additional bracing must then be added). A unit of this general design has been in use for 7 years at the Department of Plant Pathology, University of California at Los Angeles. Other similar units have been constructed in California and by the Department of Agriculture, Pretoria, South Africa; all have proved successful in operation. It is especially recommended for University and Experiment Station greenhouses and small general nurseries where compactness and versatility in a sterilizer are desirable.

When modified to have a fixed front panel, the equipment provides one of the most dependable, convenient, and efficient units available for treatment of a stationary bulk mass of soil. It may be built in any desired size, or two such units may be built in tandem so that one is steaming while the other is being filled. The latter arrangement combines the advantages of continuous-output type equipment with the efficiency of the stationary-soil type.

CONSTRUCTION AND OPERATION. — Resin-impregnated marine plyboard must be used in construction, since other plyboards will deteriorate when steamed. All inside vertical corners should be fitted with triangular pieces of wood to prevent air pockets or cold corners (Fig. 1). Pipes are arranged in 4 vertical, parallel rows (Fig. 1, 2) so that flats can be set on them or pots and cans can be lowered between the pipes from the top. Openings are provided at the top by a hinged cover and at the side by a removable front panel (Fig. 1). Bulk soil is removed by lowering the hinged reinforced bottom board (Fig. 2). This bottom piece is held in place, when closed, by 2 large bolts placed through the steel legs.

A number of devices may be used to lower the bottom when the unit is full of soil. One device illustrated uses a Yale "Pul-lift" chain hoist of ¾-ton capacity (Fig. 3, top). The "Pul-lift" operates by means of a ratchet; short strokes on the handle lower the load, and the handle cannot fly back to injure the operator. This device can be used either on a portable unit or on a stationary unit. After use, it can be removed and used for other purposes if desired. The projecting iron piece on the bottom of the cooker may interfere with shoveling of the dumped soil. Where a stationary unit is built, a chain hoist will accomplish the same lowering action provided suitable ceiling anchorage is available. Another excellent lowering device in use by the W. Atlee Burpee Co., Lompoc, California, is diagrammatically sketched in Figure 3 (bottom). This effective device lacks the mechanical simplicity and removable feature of the chain hoist or "Pul-lift" hoist, but has no obstruction to shoveling the dumped soil.

The capacity of the box is approximately 21 cu. ft. and is designed to accommodate 16 flats (18 × 18 × 3 in.). It will sterilize up to 150 empty 7-in. pots, 200 6-in. pots, or 1000 4-in. pots. The box stands 42 in. high and occupies a space approximately 42 × 52 in.

A valve located just above the lower layer of pipes (Fig. 2) can be used to shut off steam from the upper pipes; in this way, the lower layer alone may be used for treatment of flats or pots or of a small quantity of soil or sand. When this valve is open, steam is distributed to all pipes. The pipes are so located that no particle of soil is more than 6 in. from several steam outlets; thus with adequate steam input a very rapid, efficient, and uniform penetration of heat is realized. This design is an improvement of the early Rudd type of steamer[2], in which the steam was introduced through a perforated pipe in the bottom of a bin of soil 4½ ft. deep. The present unit is faster (steam moves 6 in. instead of 4½ ft.), easier to unload, and more convenient to use.

The introduction of steam through a header centered in the piping on the side of the box might be preferable for more even distribution; however, design considera-

[1] Accepted for publication January 4, 1956.

[2] Rudd, W. N. 1893. Killing grubs in soil. Amer. Florist 9 (278): 171.

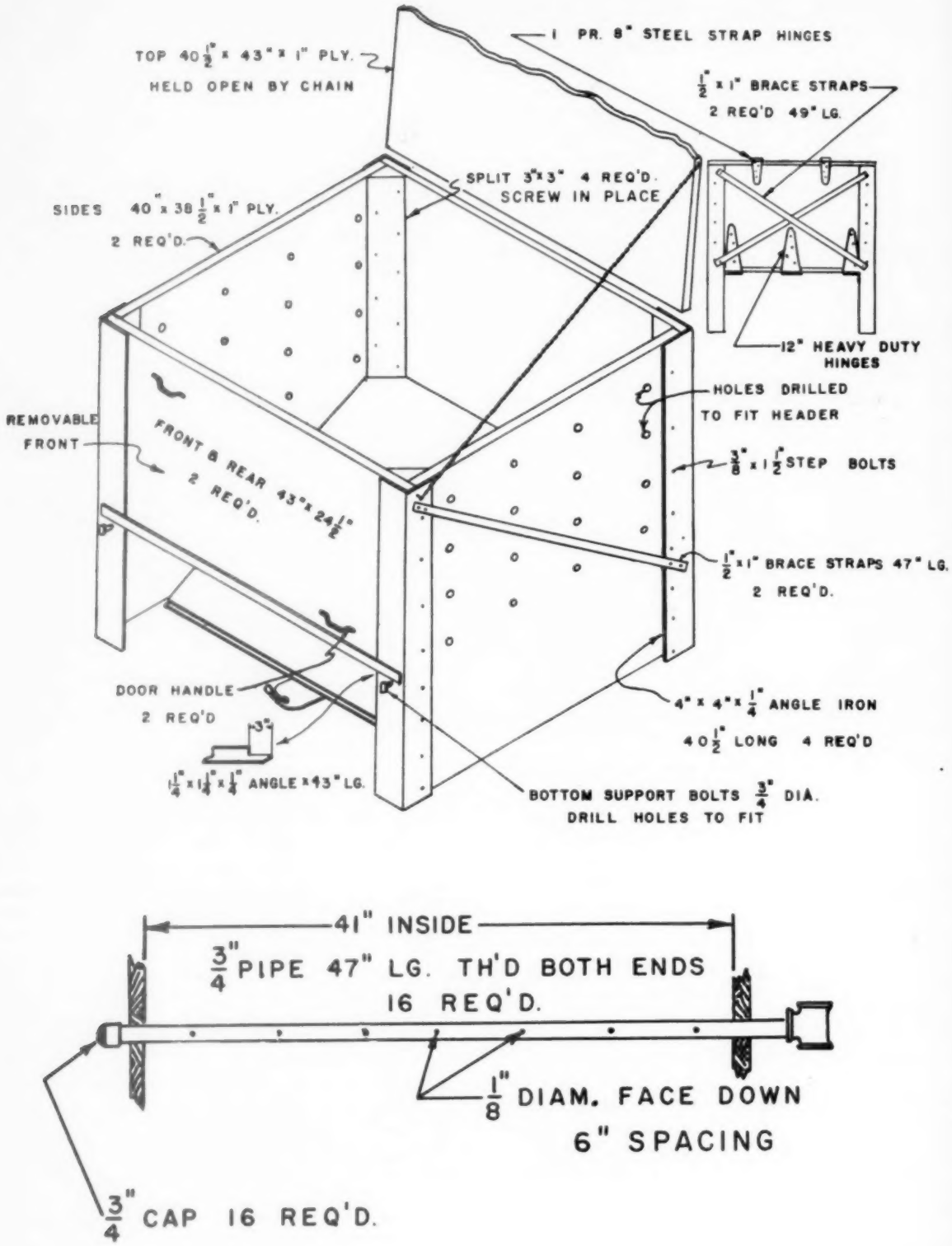

FIG. 1.—Construction details for multipurpose soil steamer. Specifications for assembly of box are shown in upper diagram. Detail of a pipe of the steam grid is shown in lower diagram.

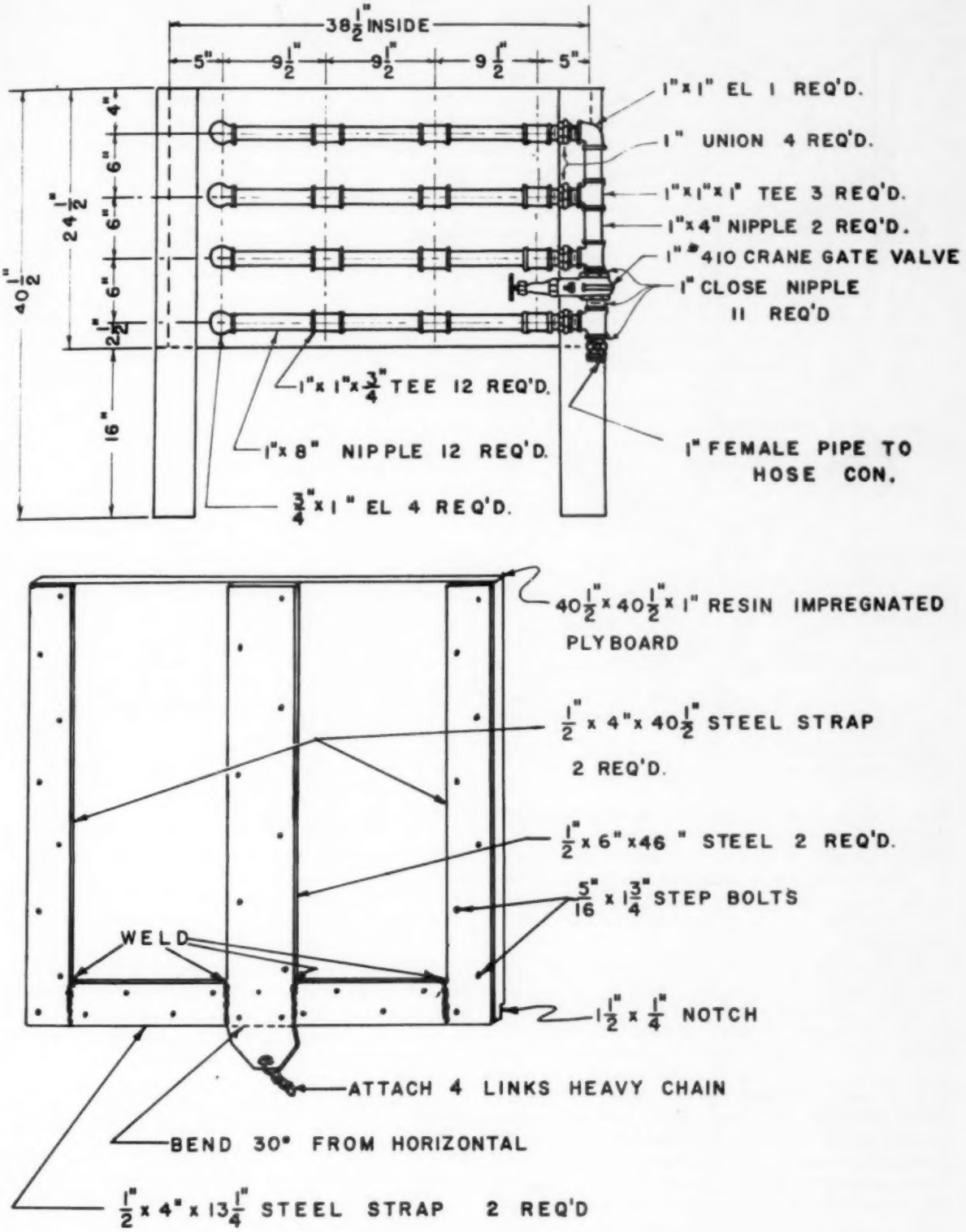

FIG. 2. Construction details for multipurpose soil steamer. Side view and assembly of piping header are shown in upper diagram. Construction of bottom drop door is shown in lower diagram. For detail of hinging of drop door see Figure 1.

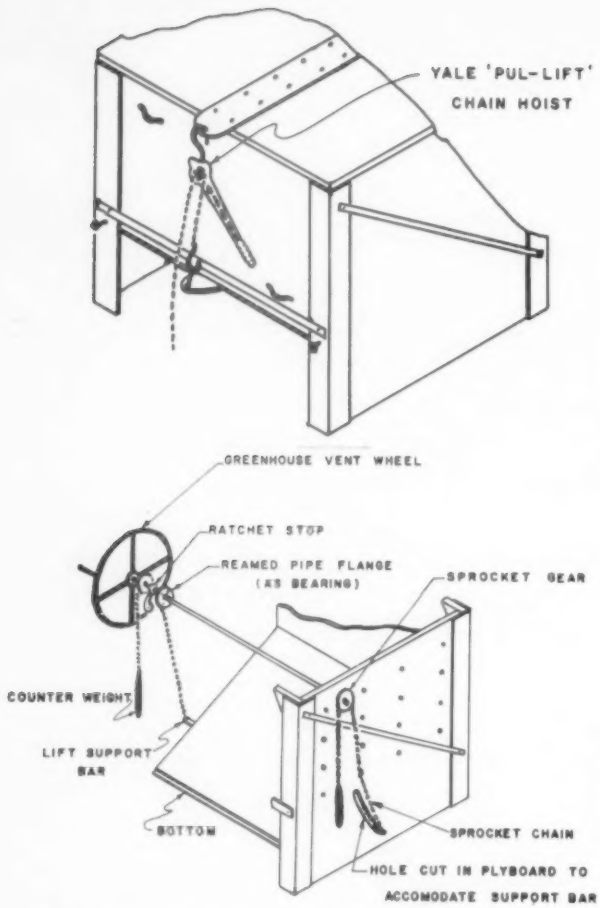

FIG. 3. Two methods for controlled lowering of the bottom of soil steamer in the dumping of the treated soil.

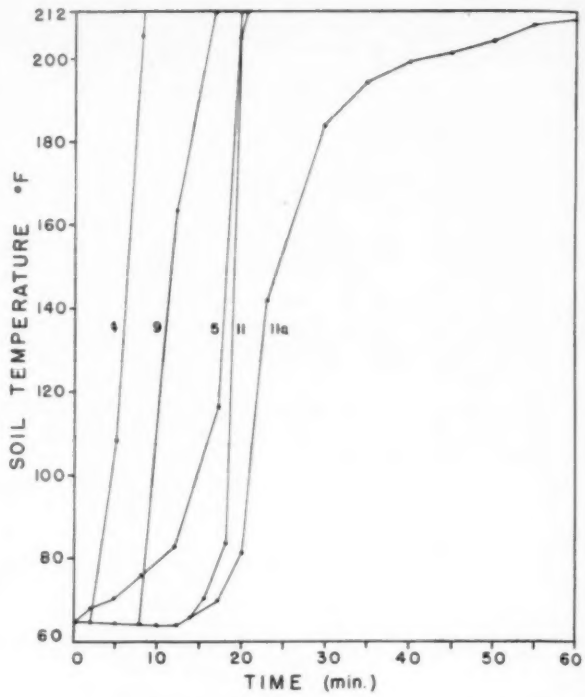

FIG. 4. Temperature rise of soil in the multipurpose soil steamer supplied with a steam flow of 148 lb./hour, in the case of thermocouples No. 1–11, and of 166 lb./hour for thermocouple No. 11a. Note that No. 11 heated much more rapidly than No. 11a, even though it was in a series with lower steam input. This resulted from the elimination of the "cold corner" by the triangular corner block. The soil used was a U. C. type mix (50 per cent fine sand and 50 per cent Canadian peat) with a 9 per cent moisture content. The curve for thermocouple No. 4 is also typical of those of No. 2, 6, and 8; that for No. 9 is also representative of those for No. 1, 3, and 7; that for No. 5 is also typical of No. 10.

tions make it desirable, and tests have demonstrated that it is feasible, to place the header at one side as shown in Figure 2. If the 4 pipe unions are loosened, the input header can be detached, and the 4 "shelves" of pipe can be slid out after the end caps are removed. Any individual pipe also can easily be removed for replacement.

EFFECTIVENESS OF UNIT.—While there are many variable factors affecting the efficiency of the soil steaming operation[3], a boiler delivering approximately 175 lb. of steam per hour (about 5 delivered boiler horsepower) through a short pipe or hose will heat moderately moist soil in this unit to 212°F in about half an hour. If long pipes or hoses are used, a boiler delivering about 260 lb./hour (7.5 boiler horsepower) may be needed. The unit may be used with free-flowing steam, with superheated steam, or with steam under pressure; in no case is the steam in the box under pressure. Thermometers should be located in the bottom corners to indicate when 212°F is reached. Should copious steam blow out of the box before this time, the main steam valve should be turned down to a trickle. For effective treatment the soil should be held at a temperature of 212°F for at least a half hour before dumping.

The usual recommendation of heating soil to 160–180°F for 30 minutes can be followed only in equipment in which the soil mass is moved past the heat source. In units with a stationary soil mass, however, it is not feasible to stop the temperature rise below 212°F because 1) steam advances through the soil as a moving front of varying width[3,4], and 2) with an efficient rate of steam flow, or close to a steam input, the rate of temperature rise is very rapid (thermocouples 4, 5, 9, and 11 of Fig. 4). In most equipment only the small amount of soil most distant from the steam input is heated to less than 212°F, and even this

[3] Morris, L. G. 1954. The steam sterilizing of soil. Experiments on fine soil. The application of research to practice. Natl. Inst. Agr. Eng. (Gr. Brit.) Repts. 14 and 24.

[4] Baker, K. F., and C. N. Roistacher. Heat treatment of nursery soils. In Diseases in relation to prepared soils for container-grown plants. Calif. Agr. Exp. Sta. Bul. (In press)

often reaches that temperature within 30 minutes after the minimal 180°F has been attained (thermocouple 11a of Fig. 4). Furthermore, the additional cost of attaining 212°F is usually insignificant, and soil toxicity from steam treatment is easily eliminated by use of an inert medium similar to a University of California type of soil mix. For these reasons, the treatment temperature for equipment with a stationary soil mass is best given as 212°F for 30 minutes, but may be stated as 180°F at the coolest point in the soil for 30 minutes[4].

The efficiency of 1 version of the pasteurizer was determined by use of thermocouples located at various points in a filled and operating unit. The model tested was made of sheet stainless steel and lost heat by radiation; the results therefore exaggerate somewhat the steam requirements to be expected of one constructed of wood. Thermocouples were located as follows: No. 1—against the bottom, centrally located; No. 2. 3. and 4—located on a diagonal between the 2 lower layers of pipes, centrally between the steam outlets (No. 2 was about 1½ in. diagonally upward from the lower pipe, No. 4 about the same distance downward from the top pipe, and No. 3 centered between them); No. 5—against a side, centrally located; No. 6, 7, and 8—same relative position as 2, 3, and 4, respectively, except located between the upper 2 layers of pipes; No. 9—on upper soil surface, centrally located; No. 10—on upper soil surface, in one corner; and No. 11—against the bottom in one corner. In 1 test a triangular piece of wood comparable to that specified for the wooden model held the thermocouple (No. 11) against the bottom and about 1½ in. from the corner.

Results of the tests showed that at a steam flow of 148 lb./hour (about 4.3 delivered boiler horsepower or 1.3 lb./hour/orifice), 212°F is attained in all parts of the unit in 30 minutes. Representative data are shown graphically in Figure 4. Comparison of readings given by thermocouples 11 and 11a shows the need of the specified triangular wood block to eliminate slow-heating "cold corners". Other tests run with steam flow rates of 68 and 75 lb./hour (about 2 boiler horsepower) showed that such a quantity is too small for effective operation of the unit. At these rates the corners reached only 110°F in 60 minutes, because of the marked heat loss and the fewer steam sources there.

Extensive use of the unit in routine soil treatment in the Department for 7 years has given completely satisfactory elimination of a wide range of pathogens from heavily infested soil. Among the many organisms eliminated were *Rhizoctonia solani* Kühn, *Pythium ultimum* Trow, *Fusarium oxysporum* f. *callistephi* (Beach) Snyd. & Hans., *Thielaviopsis basicola* (Berk. & Br.) Ferr., *Alternaria zinniae* Pape, *Verticillium albo-atrum* Reinke & Berth., *Xanthomonas pelargonii* (Brown) Starr & Burk., *Corynebacterium fascians* (Tilford) Dows., *Meloidogyne* spp., *Pratylenchus pratensis* (de Man), and tobacco mosaic virus.

The advantages of this unit lie in its rapid and efficient use of steam, its inexpensive and simple construction, its dependability and few moving parts, and its general adaptability for sterilizing various types of containers as well as bulk soil.

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A SMALL-SCALE FIELD TEST FOR EVALUATING FUNGICIDES[1]

Curt Leben,[2] Peter H. Tsao, and G. W. Keitt

SUMMARY

A small-scale field test for the evaluation of fungicides in the control of tomato early blight is described. A high level of artificial inoculum was maintained by weekly applications. Bimonthly applications were less effective. Four proprietary fungicides were tested 2 seasons, and the antibiotic oligomycin for 1. The method has merit in that land, labor, equipment, and test chemical requirements are small.

In the study and development of fungicides for the control of the leaf-spotting type of disease, there is need for small-scale field techniques capable of giving an indication of field performance of test materials. Many field tests have the weakness of placing reliance on natural inoculum for infection and of being costly in terms of the land, labor, equipment, and test chemicals necessary for their execution. Variations in the natural inoculum and the weather often prevent development of a usable level of disease each year. There may also be high interplant variability in a given season. It would be expected, then, that materials could

[1] Accepted for publication January 16, 1956. Published with approval of the Director of the Wisconsin Agricultural Experiment Station. We wish to express our thanks to Glenn S. Pound for his assistance. The oligomycin was obtained through the courtesy of Drs. Elizabeth McCoy and W. H. Peterson, of the Departments of Bacteriology and Biochemistry, respectively, University of Wisconsin.

[2] Present address: The Lilly Research Laboratories, Eli Lilly and Company, Indianapolis 6, Indiana.

be tested with less delay and with fewer numbers of plants if disease can be produced at a high level and the seasonal and interplant variables reduced. One approach to these ends is through artificial inoculation. It is obvious that the pathogen should be placed evenly on all plants. Ideally, it should be present in very large amounts. Some infection will take place under marginal environmental conditions if enough infective units are present; with a large number of infective units, therefore, a usable level of disease may be obtained even though the environmental conditions are not optimum.

With these ideas in mind, the authors devised small-scale field experiments with the early blight disease of tomato. This paper is an account of experiences with these tests during 2 growing seasons.

MATERIALS AND METHODS.—Seedling tomato plants (Bonny Best variety) were set in the field on an 8×8-ft. grid and staked. This permitted tractor cultivation. Pruning to 1 stem was continued through the first half of the growing season. There were 6 replicate plots, each of which consisted of 1 plant of each treatment. Within plots, treatments were arranged in random order.

Test chemicals were sprayed on the plants once a week, starting about 1 month after planting and continuing for 7 or 8 weeks depending on the season. Proprietary preparations were mixed in the spray tank just prior to their application to plants. Oligomycin was dissolved in ethanol before addition to the spray tank (final ethanol concentration, 5 per cent); a white microsuspension resulted. For the 6 plants of a single treatment, 3 liters or less of spray material was sufficient for each application.

From 2 to 4 days after each application of chemicals, artificial inoculation was effected by spraying chopped hyphae of *Alternaria solani* (Ell. & G. Mart.) L. R. Jones & Grout on the plants. This was done at sunset so that dew, which usually formed during the night, would provide moisture for infection.

For culturing *A. solani*, 1 liter of liquid medium (g/l: sucrose, 30; $NaNO_3$, 2; K_2HPO_4, 1; $MgSO_4 \cdot 7H_2O$, 0.5; KCl, 0.5, $Fe_2(SO_4)_3$, 0.01) per 4-liter Erlenmeyer flask was used. Flasks were plugged and autoclaved. Two or 3 flasks were seeded with a suspension of spores of *A. solani* derived from a potato-glucose agar bottle slant culture. These cultures had been seeded 1–2 weeks and kept at 20°C. No special treatment of this isolate of *A. solani* was required for the production of spores. The seeded flasks were shaken 7–10 days at 26° on a reciprocal shaker making 65 cycles per minute with a 15-cm stroke. The heavy green growth from each flask was filtered with coarse paper in a Büchner funnel and washed with 500 ml of water. The damp hyphae from 1 flask and 500 ml of water were added to a Waring blender and chopped for 3–5 minutes. The resulting suspension was filtered through coarse paper. Fragmented hyphae were resuspended in 500 ml of water and again chopped briefly. For each inoculation of plants, 2 such suspensions were pooled and diluted to 9 liters, which was the maximum amount used. This concentration left a visible deposit on the plant.

Although no spores were produced in shaken flasks, preliminary studies in the greenhouse showed that inocula prepared as above incited leaf and stem lesions indistinguishable from those incited by spores. In water drops, hyphal fragments produced young hyphae readily. Large amounts of hyphae were produced in 14-liter aerated tanks of a type used for the production of antibiotics[3]. When made into a suspension as above, this material also was highly infective. It was not used, however, because the size of the tests did not warrant the effort required to produce so large an amount of inoculum each week, and we had no information as to its infectiveness after a period of storage. The use of tank-fermentation equipment would be advantageous for extensive tests or if inocula can be stored.

Sprayers used for applying chemicals and inoculum were of the simple air-pressure back-pack type (Bugwiser No. 220B, H. D. Hudson Manufacturing Co., Chicago, Ill.). Material was applied to the plant to the point of run off.

RESULTS.—At various times and at the end of the season, the amount of disease on each plant was rated by the Horsfall-Barratt method[4,5]. Data obtained at the end of the season in each of 2 years are summarized in Table 1. For the determination of statistical significance of the data, an analysis of variance was made with the ratings, using the transformation $\sqrt{x + 1/2}$ for small numbers. On the basis of an LSD (0.05 level) of 0.26 rating unit for the 1954 data and 0.29 unit for 1955, significant treatment differences were determined with the aid of the curve provided by Horsfall,[4] page 40.

In both years artificial inocula materially increased the disease over that occurring naturally. Inoculation every week was more effective than every other week. Severe tests were given the fungicides both years. It is noted, however, that fungicides differed in their effectiveness in the 2 years. In the typical field test, this type of variation is found also. During 1954, symptoms were noted on all but the youngest parts of the plants given treatment 3 at the end of the season. Because of a drought period in the latter part of the 1955 season, however, disease was found only on the lower half of plants given the same treatment. Consequently, ratings in the 1955 tests were based only on the lower half of the plants. The fact that the disease did not increase greatly during the dry period suggests that a sprinkling system for supplemental watering would be useful in some years.

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[4] Horsfall, J. G. 1945. Fungicides and their action. Chronica Botanica Company, Waltham, Mass. 239 p.

[5] Horsfall, J. G., and R. W. Barratt. 1945. An improved grading system for measuring plant diseases. (Abs.) Phytopathology 35: 655.

TABLE 1.—*Amount of tomato early blight in small-scale field tests in which mass inoculations were made*

Treatment	Inoculum	Fungicide[a]	Percentage disease 1954[b]	1955[c]
1	Natural inoculum	None	8	5
2	Natural inoculum plus artificial inoculation every other week	None		27
3	Natural inoculum plus weekly artificial inoculation[d]	None	82	65
4	Natural inoculum plus weekly artificial inoculation[d]	Calcium copper chloride	30	7
5	Natural inoculum plus weekly artificial inoculation[d]	Captan	14	7
6	Natural inoculum plus weekly artificial inoculation[d]	Maneb	5	7
7	Natural inoculum plus weekly artificial inoculation[d]	Oligomycin		13
8	Natural inoculum plus weekly artificial inoculation[d]	Zineb	15	5

[a] Materials used were as follows: Copper A Compound (calcium copper chloride ($4Cu(OH)_2 \cdot CaCl_2 \cdot 4H_2O$); 45 per cent Cu) at 4 lb./100 gal.; Captan 50-W (50 per cent captan or *N*-(trichloromethylthio)-4-cyclohexene-1, 2-dicarboximide) at 2 lb./100 gal.; Manzate (70 per cent maneb or manganous ethylenebis[dithiocarbamate]) at 2 lb./100 gal.; oligomycin at 1.66 lb./100 gal.; and Parzate (65 per cent zineb or zinc ethylenebis[dithiocarbamate]) at 2 lb./100 gal.

[b] Differences between any 2 treatments statistically significant at the 0.05 level, except that between treatments 5 and 8, which was not significant.

[c] Differences between any 2 treatments statistically significant at the 0.05 level, except those between treatments 1 and 4, 1 and 5, 1 and 6, 1 and 8, 4 and 5, 4 and 6, 4 and 8, 5 and 6, 5 and 8, and 6 and 8, were not significant.

[d] Seven inoculations in 1954, 8 in 1955.

The results obtained with oligomycin deserve special comment. This fungicidal antibiotic[6] was tried in the field as a matter of general interest, even though 2 early blight protectant tests[7] in the greenhouse indicated that the ED_{95} was about 200 μg per ml, a concentration that is high for the control of this disease. No phytotoxic effects were observed, either in the greenhouse or in the field.

DISCUSSION.—The tests here described were designed to give information on field performance with less facilities, expense, and materials than required for the usual type of field test. The land requirement is small; there can be 10 treatments in a plot 50×80 ft. The average time necessary for tending an experiment of this size is about 3 hours per week (excluding land preparation and cultivation). The technique permits evaluation with a small amount of a candidate fungicide; when materials are in small supply, as they often are during the developmental process, this feature may be a distinct advantage. A disadvantage is that yield data on plots of this size would not be meaningful. Even with this limitation, however, it is thought that in the development of new fungicides this type of test should provide a useful link in the chain between the laboratory and widespread use on the farm.

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MILD AND SEVERE STRAINS OF TRISTEZA VIRUS IN TEXAS CITRUS[1]

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SUMMARY

Citrus seedlings of 4 varieties were bud-inoculated with tristeza virus from field sources of Matsui or Sueoka satsuma mandarin and observed for 16 months. In comparison with tristeza virus from Matsui satsuma, that from Sueoka satsuma caused chlorosis and severe stunting of Mexican lime and Red Blush grapefruit seedlings and chlorosis and reduced growth of sour orange seedlings. It had no observed effect on Cleopatra mandarin seedlings.

The symptoms on lime plants infected with virus from Sueoka satsuma were similar to or identical with the published descriptions of symptoms caused by a severe strain of tristeza virus in Brazil and other countries, where both mild and severe strains of tristeza virus occur.

A mild strain of tristeza virus from a Meyer lemon tree inhibited the development of severe symptoms in lime plants bud-inoculated with virus from Sueoka satsuma; this inhibition continued for 14 months and is evidence that the virus causing severe symptoms on lime is related to the virus causing mild symptoms. The causal agents of cachexia, exocortis, and psorosis did not inhibit the development of severe symptoms in limes bud-inoculated with virus from Sueoka satsuma; this is evidence that these viruses are not related to the virus causing severe symptoms of tristeza.

Tristeza virus has been identified in Texas citrus by bud-inoculation of Mexican lime seedlings, which serve as indicator plants for it (14). Heretofore, the symptoms produced on such indicator plants were characteristic of those produced by the mild strain in Florida (6) and by that described in California (16). The symptoms produced on Mexican lime seedlings by virus transmitted recently from a Sueoka satsuma mandarin (*Citrus reticulata* Blanco) tree, however, were more characteristic of those observed in Brazil, the Gold Coast, and South Africa, where severe strains of the virus are common; the indicator seedlings not only developed typical vein-flecking and stem pitting, but also were severely stunted and some leaves showed a corking of the veins on the upper side (Fig. 1). This observation led to an exploration of the possibility that severe strains of tristeza virus, as well as mild ones, occur in different field sources of tristeza virus in Texas citrus.

STRAINS OF VIRUS REPORTED FROM FOREIGN COUNTRIES.—In the Gold Coast of Africa, lime trees carried 2 strains of tristeza virus; one strain caused stunting and "corky vein" and "little leaf" symptoms; the other strain caused sectorial dieback of the bark (7, 8). In South Africa, McClean (10, 11) noted the same 2 strains. McClean believed that the existence of 2 strains provided a probable explanation for variations in intensity of stem pitting in grapefruit trees. In New South Wales, corking of the leaf veins of lime seedlings also occurred; this symptom was believed to occur when both tristeza and "seedling yellows" virus were present (4). In South Africa, vein corking developed in the absence of "seedling yellows" virus (12). In Brazil, Costa, Grant, and Moreira (2) noted that lime plants infected by tristeza virus showed stunting, abnormally thick bark, and yellowing of young leaves;

FIG. 1. Vein corking on the upper side of leaves of a lime seedling infected with tristeza virus from Sueoka satsuma. This plant was bud-inoculated in January, vein corking was noted in May, and the picture was taken in September.

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occasionally they noted vein splitting and corking, resembling symptoms of boron deficiency, on infected plants. These writers also noted that in Brazil infected grapefruit seedlings exhibited symptoms similar to those on grapefruit on nontolerant stocks; infected trees showed signs of deficiency, yellowing of the leaves, and leaf drop, followed by dieback and general decline of the plant.

Grant and Costa (5) presented initial evidence that plants invaded by a mild strain of tristeza virus are protected against invasion by a severe strain when exposed to it by infestation with viruliferous insects. Additional evidence for this was presented in 1954 (3). Although inconclusive, these preliminary observations suggest the possibility that relationships among viruses suspected of being strains of tristeza virus can be tested by means of cross-protection experiments.

CLASSIFICATION OF SUSPECTED STRAINS ON THE BASIS OF SYMPTOMS PRODUCED ON LIME SEEDLINGS.—The infected budwood for the experiments reported herein was taken from Mexican lime seedlings previously inoculated by means of buds or grafts from Meyer lemon and from 2 satsuma sources. Tristeza virus was known to be present in the 3 bud sources; it was not known whether all other viruses were absent.

Suspected strain from Sueoka satsuma.—Mexican lime seedlings inoculated by grafts from Sueoka satsuma showed vein clearing, yellowing and defoliation of leaves on terminal twigs, extensive stem pitting, thickened gum-impregnated bark that cut like cheese, stunted growth, and a weak root system. Leaves on flushes developing after inoculation sometimes showed corky enations along the veins on the upper side of the leaves (Fig. 1). Vein corking developed 3–6 months after initial vein clearing. These symptoms are hereafter referred to as severe symptoms of tristeza.

Suspected strain from Meyer lemon and Matsui satsuma.—Lime seedlings inoculated by grafts from a Meyer lemon at the Valley Experiment Station at Weslaco or a Matsui satsuma at Carrizo Springs made vigorous growth after initial vein clearing. The leaves remained large and green, terminal twigs did not defoliate, some stem pitting occurred under bark of normal thickness, and a strong root system was present. No vein corking appeared on the leaves. These symptoms are hereafter referred to as mild symptoms of tristeza.

EXPERIMENTS.—*Response of 4 varieties to 2 suspected virus strains.*—A limited study of the interaction between varieties and suspected strains of virus was begun in May, 1954. Cleopatra mandarin (*Citrus reticulata* Blanco), sour orange (*Citrus Aurantium* Linn.), Mexican lime (*Citrus aurantifolia* (Christmann) Swingle), and Red Blush grapefruit (*Citrus paradisi* Macf.) seedlings in gallon cans of soil were grafted with buds from lime seedlings infected with virus from 2 different satsumas. The seedlings were transplanted to a closely spaced planting in the screenhouse in January, 1955.

Seedlings of Red Blush grapefruit, Cleopatra mandarin, sour orange, and Mexican lime varied greatly in response to inoculation with virus from Sueoka or Matsui satsuma (Table 1). Grapefruit seedlings inoculated with virus from Sueoka satsuma were markedly dwarfed and had small chlorotic leaves, and some showed defoliation followed by dieback and decline; those inoculated with virus from Matsui satsuma made vigorous growth, had large green leaves, and did not show decline or branch dieback (Fig. 2). Cleopatra mandarin seedlings inoculated with virus from Sueoka satsuma were almost as vigorous as those inoculated with virus from Matsui satsuma. The leaves of sour orange seedlings inoculated with virus from Sueoka satsuma were chlorotic, and the plants made little growth during the summer of 1955; those inoculated with virus from Matsui satsuma had normal foliage color and made vigorous growth (Fig. 3). Lime plants inoculated with virus from Sueoka satsuma were stunted and showed severe symptoms of tristeza; those inoculated with virus from Matsui satsuma developed only mild symptoms (Fig. 3).

Results of cross-protection studies.—To establish the relationship between the suspected strains of tristeza virus, an experiment was initiated to determine whether a strain causing mild symptoms would protect lime seedlings against invasion by a strain causing severe symptoms. Lime plants were inoculated with virus from a Meyer lemon (*Citrus Limon* × *C. sinensis?*) tree and, after vein clearing had appeared, were reinoculated by means of lime buds carrying the virus from Sueoka satsuma. The assumption was made that the mild strain had thoroughly invaded the seedling when vein clearing appeared. The inoculated lime seedlings were set out in a closely spaced planting in the screenhouse in February, 1955. The doubly inoculated plants and the 2 singly inoculated sets of controls were observed for 14 months.

Lime plants inoculated with virus from Meyer lemon and subsequently reinoculated with virus from Sueoka satsuma did not show severe symptoms of tristeza (Table 2). Lime plants inoculated only with virus from Meyer lemon made vigorous growth and showed mild symptoms. In contrast, those inoculated only with virus from Sueoka satsuma were stunted and showed severe symptoms.

In January, 1955, lime seedlings in gallon cans of soil in a screened glasshouse were grafted with buds from 6 lime plants in each of the 3 groups listed in Table 2. The purpose of this trial was to attempt to recover the viruses introduced into the singly and doubly inoculated plants. By September, 1955, it was evident that inoculation with buds from these inoculated plants caused the same responses on another batch of lime seedlings as did the original inoculations, alone and combined. Inoculation with buds from plants with mild symptoms caused mild symptoms; inoculation with buds from plants with severe symptoms caused severe symptoms on the second batch of lime seedlings.

To determine whether other viruses common in

TABLE 1.—*Reaction of 4 kinds of citrus seedlings to inoculation with lime buds infected with 2 suspected strains of tristeza virus*

Seedling variety that was bud-inoculated	Suspected virus strain in bud-inoculation[a]	Budded seedlings yielding tristeza virus[b]	Height of seedlings at indicated interval after bud-inoculation[c]		Color of foliage, 16 months after budding
			13 months	16 months	
		No.	In.	In.	
Grapefruit					
Red Blush	Severe	6	15	16	Chlorotic
Red Blush	Mild	3	42	72	Green
Mandarin					
Cleopatra	Severe	4	41	69	Green
Cleopatra	Mild	0	45	75	Green
Sour orange					
Texas sour	Severe	6	32	33	Chlorotic
Texas sour	Mild	2	39	54	Green
Lime					
Mexican	Severe	6	22	23	Chlorotic
Mexican	Mild	6	35	48	Green

[a] Origin of suspected virus strains carried in lime budwood: mild strain, a Matsui satsuma; severe strain, a Sueoka satsuma.

[b] Thirteen months after inoculation, buds from each of the 6 plants in each treatment were grafted to Mexican lime seedlings, indicator plants for tristeza virus, and the number of bud sources causing tristeza symptoms on lime seedlings was recorded. Tests at a later date with some plants, such as Cleopatra mandarin seedlings inoculated with the mild strain, indicated that buds from some branches carried virus, while those from other branches did not cause tristeza symptoms on budded lime seedlings.

[c] Average of 6 plants (2-plant groups replicated 3 times).

LSD between virus sources as follows:

	13 months	*16 months*
0.01 level	9	15
0.05 level	7	11

Texas citrus interfere with the development of severe symptoms of tristeza. 9 groups of lime plants were bud-inoculated with psorosis virus from field trees of Dancy tangerine, Mexican lime, Eureka lemon, Washington navel orange, and Temple orange; these trees may carry other viruses. Two other groups of lime plants were bud-inoculated at the same time with tristeza virus from a Meyer lemon. After psorosis or mild tristeza symptoms had developed on the lime test plants, they were reinoculated by means of lime buds carrying the virus from Sueoka satsuma. These plants were observed for 6 months.

Lime plants bud-inoculated with psorosis virus and possibly with other viruses from field trees of 5 common varieties and reinoculated with virus from Sueoka satsuma developed severe symptoms of tristeza. Lime plants bud-inoculated with virus from a Meyer lemon and subsequently reinoculated with virus from Sueoka satsuma showed only mild symptoms, however, and 6 months after budding were twice as tall as those showing severe symptoms; the control lime plants, bud-inoculated with virus from Sueoka satsuma, developed severe symptoms.

A year-old Red Blush grapefruit tree on sour orange rootstock, known to carry the causal agents of cachexia and exocortis diseases, was bud-inoculated with lime buds carrying the virus from Sueoka satsuma; 4 months after inoculation, grapefruit buds from this tree were grafted to a group of Mexican lime seedlings, which were observed for 3 months. Severe symptoms also developed on these lime seedlings.

DISCUSSION.—The majority of the cross-immunity studies have been carried out with viruses that are mechanically transmissible, but it has been determined that peach yellows and little peach viruses will protect against each other when inoculations are made by

TABLE 2.—*Reaction of Mexican lime plants on September, 1955, to budding with lime buds carrying tristeza virus from Meyer lemon or Sueoka satsuma, or both, in May and/or July, 1954*

Virus source used in May	Virus source used in July	Lime seedlings per treatment	Plants showing		Average height of seedlings
			Vein clearing and stem pitting	Severe symptoms[a]	
		No.	No.	No.	In.
Meyer lemon	None	12	12	0	47
None	Sueoka satsuma	11	11	11	27
Meyer lemon	Sueoka satsuma	8	8	0	46

[a] Severe symptoms: vein corking sometimes occurring on the upper side of 1 or several leaves, defoliation of terminal branches followed by growth of small leaves on short lateral shoots from defoliated branches, heavy gum deposits in inner bark, stunted growth, and a weak root system.

FIG. 2. Red Blush grapefruit seedlings, either noninoculated or infected with tristeza virus (16 months after inoculation). The ruler at far left is 1 ft. long. A) Two plants carrying virus from Sueoka satsuma. B) Two plants carrying virus from Matsui satsuma. C) Two noninoculated plants.

means of grafts (9). It has been shown for numerous groups of viruses that plant tissues invaded by one strain of a virus are protected from invasion by another strain of the same virus, but are susceptible to infection by unrelated viruses (15). Plants are protected from infection or invasion, however, only if they are already fully invaded by a virus related to the one being introduced; noninvaded portions of diseased plants remain susceptible to invasion by a second related virus (1).

The mild virus strain from 1 Meyer lemon tree inhibited the development of severe symptoms in limes bud-inoculated with virus from Sueoka satsuma; this inhibition continued through the 14-month period of the experiment and is evidence that a virus causing severe symptoms on limes is related to the virus causing mild symptoms. On the basis of the results in Table 2, it seems probable that a virus from Sueoka satsuma is a severe strain, whereas the virus from a Meyer lemon is a mild one.

Virus strains from other Meyer lemon or Sueoka satsuma trees are not necessarily identical with the ones tested. The Sueoka satsuma was originally introduced into this country from Japan. The virus source in these experiments was a tree on rootstock of *Poncirus trifoliata* planted in 1932 at Carrizo Springs. At the time of its destruction in 1955, there was no evidence of cachexia disease in the cachexia-susceptible top and no evidence of exocortis disease in the exocortis-susceptible rootstock; psorosis was not detected in its budded progeny. Since other viruses might be present in the Sueoka satsuma, it would be desirable to separate tristeza virus from other possible components. Aphid transmission of the virus would be expected to leave behind viruses that are bud-transmitted but not aphid-transmitted. Aphid transmission tests in Texas have not been successful to date, however, and plant material known to carry only insect-transmitted virus was not available in these tests. Cachexia, exocortis, and psorosis diseases occur in some grapefruit field trees free of tristeza virus (13 and unpublished data). The causal agents of cachexia, exocortis, and psorosis did not inhibit the development of severe symptoms in limes bud-inoculated with virus from Sueoka satsuma; this is further evidence that these viruses are not related to the severe strain of tristeza.

The corking of the veins on the upper side of some

FIG. 3. Sour orange and Mexican lime seedlings infected with tristeza virus, 16 months after inoculation. The ruler at far right is 1 ft. long. The 2-plant groups are A) Mexican limes carrying virus from Matsui satsuma, B) Stunted Mexican limes carrying virus from Sueoka satsuma, C) Sour oranges carrying virus from Matsui satsuma, and D) Defoliated or chlorotic sour oranges carrying virus from Sueoka satsuma.

leaves of lime plants showing severe symptoms resembled the corking and splitting of the veins associated with boron deficiency; however, boron deficiency is unknown in citrus in the Lower Rio Grande Valley. In this area, boron is abundant in soil and water, and boron-toxicity symptoms are commonplace. Each of 2 samples of lime leaves, one with vein corking and the other with mild tristeza symptoms, contained more than 100 ppm boron on a dry-weight basis; these values are too high for plants to be considered boron-deficient.

Whereas the vein-corking symptom is conspicuous, it is not a consistent symptom of infection by virus from Sueoka satsuma. Sometimes vein corking appeared on leaves that were immature at time of inoculation with virus; at other times it occurred on 1 or several leaves of new flush developing after inoculation, and at still other times it did not occur during the 3- to 8-month period of observation. The vein-corking symptom, however, developed in lime seedlings inoculated by buds, twig grafts, and grafts of leaf pieces, with or without vein corking. Hughes and Lister (8) noted that vein corking in limes was often observed in experimental plants but was rare in field plantings. Costa, Grant, and Moreira (2) occasionally found vein corking on lime plants in field plantings in Brazil. The plants in Texas were grown under screenhouse and glasshouse conditions; it is doubtful that stunted plants with severe tristeza symptoms would survive in a field planting. It seems probable that the expression of vein corking in Texas is an interaction between plant environment and infection with virus from Sueoka satsuma. Thus, vein corking is probably a secondary symptom following damage to roots and phloem by virus infection and may occur despite adequate supplies of essential minerals in the soil.

CITRUS ROOTSTOCK INVESTIGATIONS
U .S. DEPARTMENT OF AGRICULTURE
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PHYTOPATHOLOGICAL NOTES

The Mode of Action of Antibiotics in the Control of Plant Disease.[1] D. PRAMER, R. S. ROBISON, AND R. L. STARKEY. An antibiotic may control plant disease 1) by acting directly on the pathogen; 2) by neutralizing toxins secreted by the pathogen; 3) by acting on the host; 4) by being transformed within the plant to a substance having greater or different activity; or 5) by a combination of 2 or more of the possibilities listed.

In vitro studies[2,3] show that antibiotics suppress the growth of many plant pathogens. It has been assumed, but never demonstrated, that direct action of the antibiotic on the pathogen is similarly responsible for results obtained *in vivo*. Recent reports[4,5,6] that describe control of a pathogen *in vivo* by an antibiotic having no activity *in vitro* can be explained only by an indirect mode of action.

To our knowledge, the literature contains no information regarding the ability of antibiotics to neutralize toxins secreted by plant pathogens. Likewise, we know little of how antibiotics may alter the metabolism of plants and thereby confer resistance to infection.

Though disease control may be achieved by forms of antibiotics produced as a result of their alteration within the plant, there is some evidence that this does not occur. Crowdy, Grove, and Pramer[7] isolated pure griseofulvin from treated plants, and Pramer[8] provided evidence, based on R_f values obtained from paper chromatograms of plant sap, that both streptomycin and chloramphenicol remained essentially unaltered in treated plants.

Klemmer, Riker, and Allen[9] showed that the inhibition of crown gall by antibiotics results from an indirect mode of action. It was found that chlortetracycline, oxytetracycline, and chloramphenicol were toxic to gall cells but nontoxic to normal plant cells. Antibiotic-resistant strains of the pathogen were used to advantage in demonstrating that lack of gall formation in inoculated plants was due to toxicity of the antibiotic to the gall cells and not to susceptibility of the pathogen to the antibiotic. Through independent but similar reasoning and experimentation, we have isolated streptomycin-resistant strains of *Erwinia chrysanthemi* Burk., McFadden, & Dimock and have employed them in an effort to define the mode of action of streptomycin in the control of bacterial wilt of chrysanthemums (*Chrysanthemum morifolium* Ram.).

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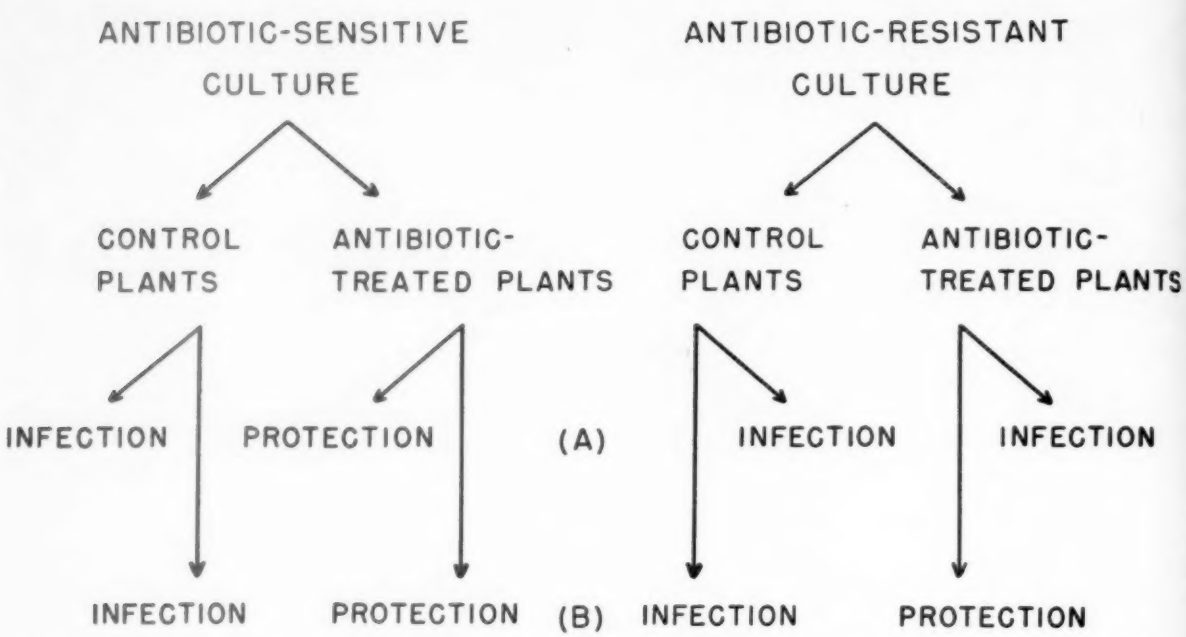

FIG. 1. Schematic representation of a procedure using antibiotic-sensitive and antibiotic-resistant strains of phytopathogens to determine the mode of action of antibiotics in the control of plant diseases. Results in line A (wilt of chrysanthemum) indicate that protection is due to direct action of the antibiotic on the pathogen. Results in line B (crown gall) indicate protection is due to an indirect mode of action.

Figure 1 shows how antibiotic-sensitive and antibiotic-resistant cultures were used to determine whether disease control resulted from a direct or an indirect mode of action.

Growth of *E. chrysanthemi* was inhibited completely by 5 ppm of streptomycin. Strains resistant to 1000 ppm were isolated by 4 serial transfers in yeast-dextrose broth containing graded concentrations of the antibiotic, or by direct transfer of the sensitive culture to broth containing 1000 ppm of streptomycin. The virulence of the antibiotic-resistant culture was established by tests on unrooted and rooted cuttings. Previously described procedures[10] were used in these tests.

Unrooted cuttings were treated with the antibiotic by immersing the stems for 5 hours in solutions containing 125 ppm of streptomycin. Half of the treated and half of the control cuttings were inoculated with the streptomycin-sensitive pathogen, and the remaining ones were inoculated with the streptomycin-resistant pathogen. The cuttings were maintained in test tubes containing tap water. In a similar experiment, cuttings rooted in sand were treated with 50 ppm of streptomycin. In each case the antibiotic-resistant strain of *E. chrysanthemi* produced disease symptoms in both the streptomycin-treated and control cuttings, whereas the antibiotic-sensitive strain infected only the control cuttings. These results, indicated on line A of Figure 1, establish that the control of bacterial wilt of chrysanthemums by streptomycin results from direct action of the antibiotic on the pathogen. The observations of Klemmer, Riker, and Allen,[9] indicated on line B of Figure 1, show that the inhibition of crown gall by antibiotics results from an indirect mode of action. —Department of Agricultural Microbiology, New Jersey Agricultural Experiment Station, New Brunswick, New Jersey.

[10] Robison, R. S., R. L. Starkey, and O. W. Davidson. 1954. Control of bacterial wilt of chrysanthemums with streptomycin. Phytopathology 44: 646-650.

Effect of Storage on the Fungicide Content of Oat Seed Treated with Mercury Compounds.[1] D. C. ARNY AND CURT LEBEN.[2] Our investigations on the vapor action of the organic mercury compounds[3] indicated that the vapors of different materials were taken up in varying amounts by oat seed. More recently, the permanence of these materials on treated seed has been investigated. This note is a report of periodic tests on the fungicidal activity of 2 materials on treated seed stored in closed bottles or exposed to air.

Two of the materials used in the previous tests were

[1] Published with the approval of the director of the Wisconsin Agricultural Experiment Station. Supported in part by the Research Committee of the Graduate School from funds supplied by the Wisconsin Alumni Research Foundation.

[2] Present address of C. Leben: The Lilly Research Laboratories, Eli Lilly and Company, Indianapolis, Indiana.

[3] Arny, D. C., and C. Leben. 1954. Vapor action of certain mercury seed treatment materials. Phytopathology 44: 380-383.

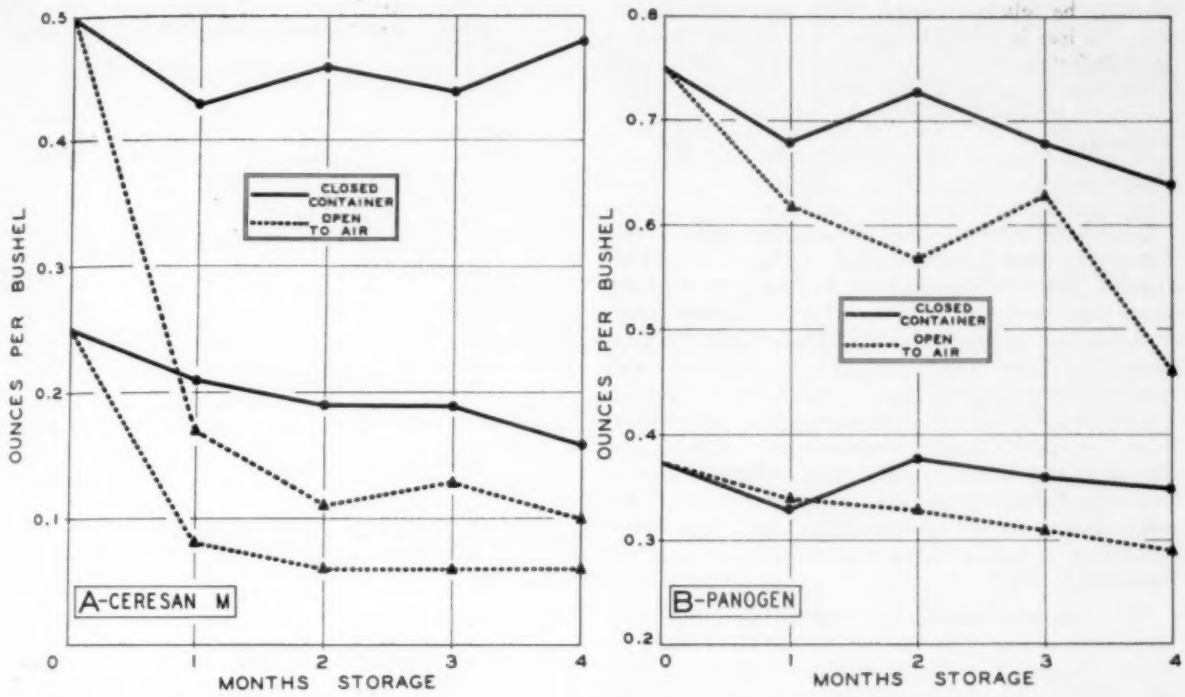

FIG. 1. Amounts of fungicide present on treated oat seed after varying periods of storage in closed containers or in the open air. A) Seed treated with Ceresan M at 0.5 and 0.25 ounces per bushel at beginning of experiment. B) Seed treated with Panogen at 0.75 and 0.375 fluid ounces per bushel at beginning of experiment.

studied. Ceresan M (7.7 per cent *N*-(ethylmercuri)-*p*-toluenesulfonanilide) and Panogen (2.2 per cent cyano(methylmercuri)guanidine) were applied to oat seed at 2 rates, 0.5 and 0.25 ounces per bushel for Ceresan M, and 0.75 and 0.375 fluid ounces per bushel for Panogen. Treatment was carried out in small (200 ml) screw-cap bottles with 50 g of seed per treatment. Treated seed was stored in closed bottles for 7–9 days. At the end of this time, a small amount of seed from each treatment was spread in a single layer on the bottom of an open Petri dish. The remaining seed was left in the original capped treating bottle, which was opened briefly only when samples were removed for assay. All treated seed was stored at 26°C. Determinations of the amount of fungicides present were made at 1, 2, 3, and 4 months after treatment, using the Glomerella agar plate test[3,4]. This assay method is dependent upon the diffusion of fungicides from the seeds into an agar medium containing conidia of *G. cingulata* (Ston.) Spauld. & Schrenk. After a period of incubation, inhibition zones are produced around seeds carrying fungicides. The amount of a particular fungicide present in a given sample is estimated by comparison of the diameter of zones around seeds from the test sample with the diameter of zones produced by the standards, i.e. seeds treated with graded amounts of the same fungicide. New standards for each assay were prepared approximately 1 week prior to assay. There were 4 different experiments and 4 assays for the 1-month period, 3 experiments and 3 assays for the 2-month period, 2 for the 3-month period, and 1 for the 4-month period.

Fungicidal activity of both chemicals was lost more rapidly from seed stored in the open than from that kept in closed bottles (Fig. 1). Under the open storage conditions, the activity of Ceresan M was lost more rapidly than that of Panogen. The loss of volatile compounds from seed stored in closed bottles possibly was due to the escape of vapor when the bottles were opened to remove samples for assay. These data were verified in another experiment that was discontinued at the end of 2 months. According to Koehler and Bever[5], the closed-bottle storage test was more severe than commercial storage conditions but more closely simulated commercial conditions than did exposure to air.

In treated seed stored exposed to the air for long periods, the loss of fungicidal activity could be of importance in relation to protectant action against soil-borne organisms. As seed is ordinarily handled, however, only a small proportion is exposed to air, and the decline in activity under these conditions is be-

[4] Arny, D. C. 1952. The bioassay of Ceresan M on treated oat kernels. Phytopathology 42: 222-223.

[5] Koehler, B., and W. M. Bever. 1954. Oat and wheat seed treatments: methods, injuries and gains. U. S. Dept. Agr. Pl. Dis. Rptr. 38: 762-768.

lieved to be relatively small. With seed-borne pathogens, the loss is probably not of consequence because the disinfectant action is presumed to take place early in the storage period.—Departments of Plant Pathology and Agronomy, University of Wisconsin, Madison, Wisconsin.

Control of Several Small Grain Diseases by the Water-soak Seed Treatment.[1] D. C. Arny and Curt Leben.[2] The water-soak seed treatment method of Tyner has been found to be effective against loose smut of barley (incited by *Ustilago nuda* (Jens.) Rostr.)[3,4]. Tyner also noted that it controlled loose smut of wheat (incited by *U. tritici* (Pers.) Rostr.). Wallen and Skolko[5] reported that soaking pea seed in water greatly reduced seed-borne infection by *Ascochyta pisi* Lib. The effectiveness of the treatment for these diseases suggested a study of its effect on other diseases incited by seed-borne fungi. This paper presents a record of these studies. An abstract has appeared earlier[6].

The 3 diseases studied most extensively were seedling blight of oats (on Victland, C.I. 3611) incited by *Helminthosporium victoriae* Meehan & Murphy, seedling blight of barley (on Wisconsin Barbless, C.I. 5105) incited by *H. sativum* Pam., King, & Bakke, and stripe of barley (on Atlas, C.I. 4118[7]) incited by *H. gramineum* Rab. In each case the seed was naturally infested. Limited tests also have been made with wheat bunt (incited by *Tilletia foetida* (Wallr.) Liro), wheat loose smut, barley covered smut (incited by *U. hordei* (Pers.) Lager.), and oat smuts (incited by *U. avenae* (Pers.) Rostr. and *U. kolleri* Wille).

Seed was soaked in distilled water in open Erlenmeyer flasks at 24–26°C for 56 hours. Usually, 20 g of seed were used per 100 ml of water. After the seed was dried on screens at room temperature, plantings for most tests were made in soil in the greenhouse to determine germination and disease. In all tests, seed treated with Ceresan M (7.7 per cent *N*-(ethylmercuri)-*p*-toluenesulfonanilide) was included for comparative purposes. Seed treated with Ceresan M was stored 7–10 days in a tight container before planting.

Table 1.—*The control of 3 small grain diseases by the water-soak seed treatment compared with the standard, Ceresan M*

Disease and pathogen	Treatment	Percentage germination[a]	Percentage diseased plants[a]
Seedling blight of oats (*H victoriae*)[b]	None	90	41
	Ceresan M	89	3
	Water soak	81	6
Seedling blight of barley (*H. sativum*)[c]	None	94	54
	Ceresan M	96	5
	Water soak	87	11
Barley stripe (*H. gramineum*)[d]	None	70	7
	Ceresan M	75	0
	Water soak	67	0

[a] For each treatment of a trial, 3 replicates of 50 seeds were planted.
[b] Two seed lots, 1 trial with first lot, and 2 trials with second.
[c] Seven seed lots, 1 trial each.
[d] One seed lot, 3 trials. One trial was grown in the field by C. W. Schaller at Davis, California. Three replicates of 100 seeds each were used.

The water-soak treatment reduced the germination slightly (Table 1). The seedling blights of oats and barley were reduced markedly by the water soak. The control given by Ceresan M was only slightly better. While the number of striped plants that developed in the nontreated Atlas was low, the disease was eliminated both by the water soak and by Ceresan M. Field tests with winter wheat have shown that infection by the bunt fungus also can be materially reduced by the water soak, although with this disease the control may have been due in part to the removal of spores by washing. Limited field tests with loose smut of spring and winter wheats, covered smut of barley, and the oat smuts indicate that these diseases also can be reduced or eliminated by the water soak.

Nontreated and soaked lots of barley seeds of various varieties were plated on malt-salt agar (7.5 per cent NaCl and 2 per cent malt extract). Seeds were first surface sterilized with a mixture of ethanol and sodium hypochlorite. The organisms that grew from seeds are given in Table 2. *Alternaria* spp. were markedly reduced by the water soak. *Fusarium* spp. and *Helminthosporium* spp. also appeared less frequently from soaked seeds than from untreated ones. The percentage of bacteria increased rather markedly on soaked seeds. Plating tests with Atlas (data not recorded in Table 2) were particularly striking in that *H. gramineum* was present on 55 per cent of the nontreated seeds, whereas the fungus grew from none of the soaked seeds. These plating tests show that the flora present on the seed is materially changed by the soaking treatment and that several pathogenic organisms are eliminated or reduced in numbers.

[1] Published with the approval of the Director of the Wisconsin Agricultural Experiment Station. Supported in part by the Research Committee of the Graduate School with funds supplied by the Wisconsin Alumni Research Foundation.
[2] Present address of Curt Leben: The Lilly Research Laboratories, Eli Lilly and Company, Indianapolis, Indiana.
[3] Tyner, L. E. 1953. The control of loose smut of barley and wheat by Spergon and by soaking in water at room temperature. Phytopathology 43: 313-316.
[4] Leben, C., and D. C. Arny. 1954. Soaking treatments for the control of loose smut of barley. Phytopathology 44: 329-330.
[5] Wallen, V. R., and Skolko, A. J. 1953. The inactivation of antifungal antibiotics by chlorine. U. S. Dept. Agri. Pl. Dis. Rptr. 37: 421-424.
[6] Arny, D. C., and C. Leben. 1954. Control of several small grain diseases by the water soak method. (Abs.) Phytopathology 44: 481.
[7] Seed supplied by C. A. Suneson, Agronomy Department, University of California, Davis, California.

TABLE 2.—*Organisms that grew from nontreated and water-soaked barley seeds that were surface sterilized and plated on malt-salt agar*

Type of organism	Percentage of seeds with given organism[a]	
	Nontreated	Soaked
Alternaria spp.	50	1
Fusarium spp.	6	1
Helminthosporium spp.	9	1
Storage molds[b]	9	8
Bacteria	62	91
None	2	6

[a] Each figure is based on an average of 20 seeds from each of 17 different seed lots.
[b] *Aspergillus* spp., *Penicillium* spp., etc.

The water-soak treatment is not specific for *U. nuda* and *U. tritici*. This fact may be useful in investigations on the physiologic processes involved and the chemical compounds formed in the water-soak treatment. Tests with the *Helminthosporium* seedling blights can be made in 3–4 weeks in contrast with 2–3 months for loose smuts. Ultimately, of course, it will be necessary to establish whether control of the seedling diseases has the same basis as the control of the loose smuts.—Departments of Plant Pathology and Agronomy, University of Wisconsin, Madison, Wisconsin.

Spray Gun for Greenhouse Inoculations. R. A. KILPATRICK AND HOWARD W. JOHNSON[1]. The spray equipment used by plant pathologists for greenhouse inoculations usually is a small atomizer or a small tank-type compressed-air sprayer, both of which emit a fine mist. A shredded mycelial suspension is frequently too coarse to go through the spray nozzle and periodic cleaning is necessary. During the investigations on soybean diseases at Stoneville, Mississippi, a different type of spray gun was tried and was proved to be quite satisfactory for both bacterial and fungus inoculations.

The Schrader spray gun (Fig. 1, A) consists of a complete spray unit that connects to an air line operating on 15–20 lb. pressure. The rear portion of the gun has a trigger-like attachment for permitting passage of air. The intake tube marked "water" has a valve core that is easily removed and permits passage of suspensions varying in density. In operation, a 6- to 10-in. length of rubber tubing is attached to this opening so that water or inoculum can be sprayed from a flask or beaker. When more than 1 organism is being used for inoculations, the end of the sprayer

[1] Pathologist and Senior Pathologist, respectively, Field Crops Research Branch, Agricultural Research Service, U. S. Department of Agriculture, and Mississippi Agricultural Experiment Station, cooperating.

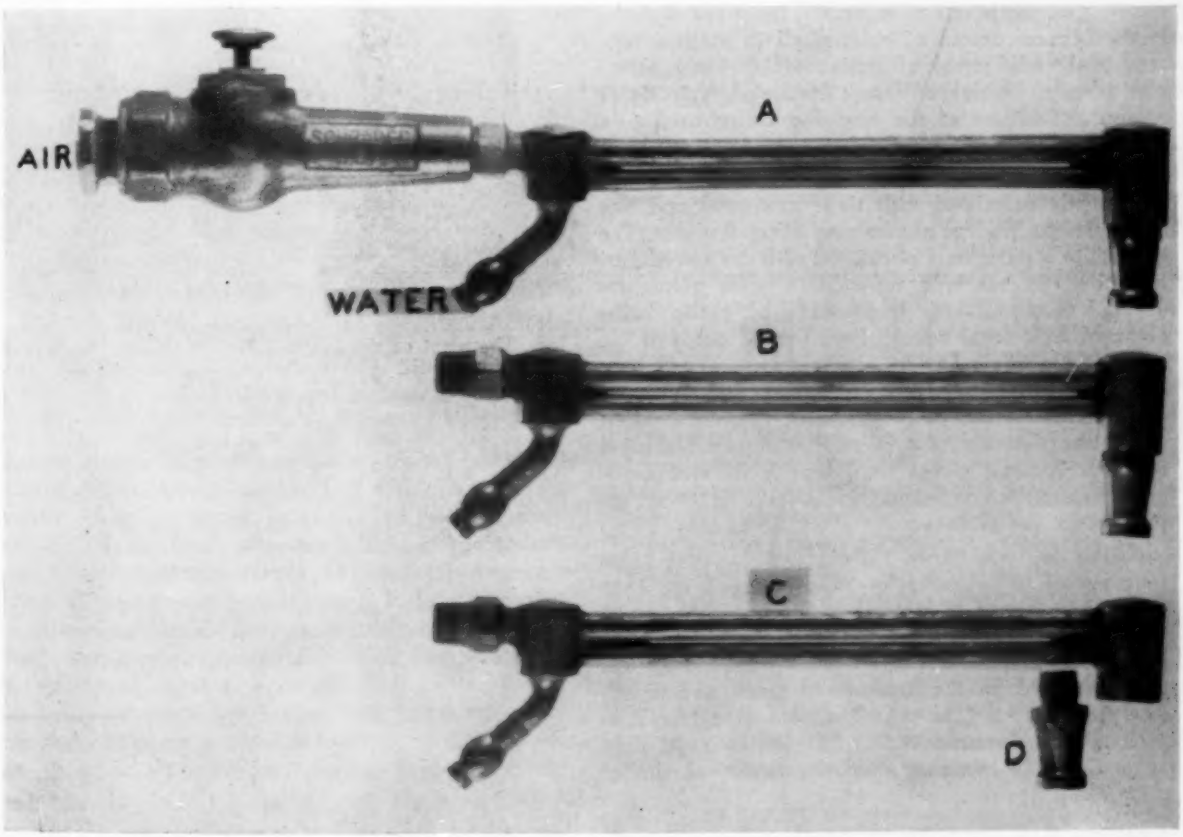

FIG. 1. A) Complete Schrader spray gun. B, C) Removable nozzle. D) Adjustable tip. (×⅔).

(Fig. 1, B) can be removed and another connected. The spray tip (Fig. 1, D) can be adjusted on the gun (Fig. 1, C) for suspensions of varying density. After inoculations are completed, the end of the sprayer (Fig. 1, B) can be unscrewed from the air valve and autoclaved without injury, since there are no rubber gaskets and heat does not injure the equipment.

The Schrader spray equipment (A. Schrader's Son, Brooklyn 38, N. Y.) is easily operated by one hand, leaving the other hand free for movement of plants to be inoculated. Good results have been obtained with suspensions of both agar and leaves triturated in liquid, since the size of the orifice in Figure 1, C is 2 mm. A complete spray unit (Fig. 1, A) is inexpensive and where more than 1 fungus or bacterial suspension is being inoculated it is highly desirable to have extra sprayers (Fig. 1, B) that can be purchased separately.—Delta Branch Mississippi Agricultural Experiment Station, Stoneville, Mississippi.

The Production on Garlic by an Eriophyid Mite of Symptoms Like Those Produced by Viruses. EUGENE B. SMALLEY. Symptoms resembling those sometimes caused by viruses, but differing from those of garlic mosaic, were noted in many field plantings of California Late garlic during the 1954 season. Early symptoms included twisting and streaking of the leaves and dwarfing of the plants. Frequently, large areas of the leaves became devoid of chlorophyll in marked contrast to the mild streak of garlic mosaic. Later, a tangled mass of interlooped leaves developed, typically as a result of failure of the emerging leaves to disjoin (Fig. 1).

The eriophyid mite, *Aceria tulipae* Keifer, was found consistently associated with these symptoms and was often present in large numbers on affected plants. The same mite is commonly associated with dry stored garlic bulbs and has been reported to cause premature drying.[1] Examinations were made of garlic bulbs obtained from local stores; from several fields of the varieties California Early, California Late, and Oregon Late; and from imported Hungarian and Japanese strains. All of the bulbs examined contained mites, suggesting that the mite is more widespread than is realized. Planted cloves from heavily infested bulbs always developed symptoms identical with those appearing in the field.

California Late garlic cloves from infested bulbs were peeled and selected for uniformity of size. They were then surface disinfested in 10 per cent Clorox (5.25 per cent sodium hypochlorite) for 10 minutes and air dried at 35°C for 10 minutes. Each clove was then inspected for the presence of mites, and if free was planted in a 6-in. pot. The pots were placed in a chamber maintained at 20°C for 10 hours of light at 10°C for 14 hours of darkness, conditions similar to natural growing conditions during the early part of the season. After 6 days, the young healthy plants were infested by means of pieces of garlic leaves containing colonies of the mite placed in the folds of emerging leaves. The experiment was carried out twice; a total of 6 noninfested plants and 10 artificially infested plants were used. Mites for infestation were obtained from field-infested plants and from stored garlic. After 22 days, a large population of mites developed and typical symptoms appeared on the artificially infested plants, whereas noninfested plants remained symptomless (Fig. 1).

FIG. 1. California Late garlic plants 28 days after planting. The plant on the left is a healthy check; the other 3 are mite-infested plants showing typical twisting and streaking.

Sections made through infested leaves showed that the cells of the upper epidermis had been completely collapsed by the mite feeding. Routine electron micro-

[1] Keifer, H. H. 1952. The Eriophyid mites of California. Calif. Insect Survey Bul. 2 (1): 33.

graphs made from crude preparations of ground leaves showed no differences between those from infested plants and those from noninfested plants.

At the conclusion of the infestation experiments, the plants were transferred to a lath house. When almost mature, the bulbs were removed from the pots and the cloves were dissected out, disinfested in 10 per cent Clorox, stored at 5°C, and planted the following spring in the field. The resulting plants showed none of the typical symptoms, indicating that the original symptoms were the result of feeding by eriophyid mites and that they were not of virus origin.—Department of Plant Pathology, University of California, Berkeley 4, California.

The Tristeza Virus in Israel.[1] J. M. WALLACE,[2] I. REICHERT,[3] A. BENTAL,[3] AND E. WINOCOUR.[3] In connection with investigations on the possible presence of tristeza in Israel, a number of citrus varieties established from foreign importations were examined. One particular variety, the Meyer lemon, was given special attention because it has consistently shown complete decline on sour orange rootstock in Israel and has also been reported in the United States to be a carrier of the tristeza virus.[4,5] All the Meyer lemon trees established in Israel derive from a single budwood parent that was imported in 1932 from California.

Scion twigs were collected from 3 Meyer lemon trees and grafted into the stems of decapitated Mexican lime seedlings that had been grown from seeds in the open. Two graft-inoculation methods were used: 1) the side-graft technique used by the senior author[6] for transmission of citrus viruses and, 2) the bottle-graft described by Bennett and Costa.[7] After approximately 4 weeks, the newly developed leaves of the inoculated seedlings, when viewed in transmitted light, showed distinctly cleared areas on some of the veins.

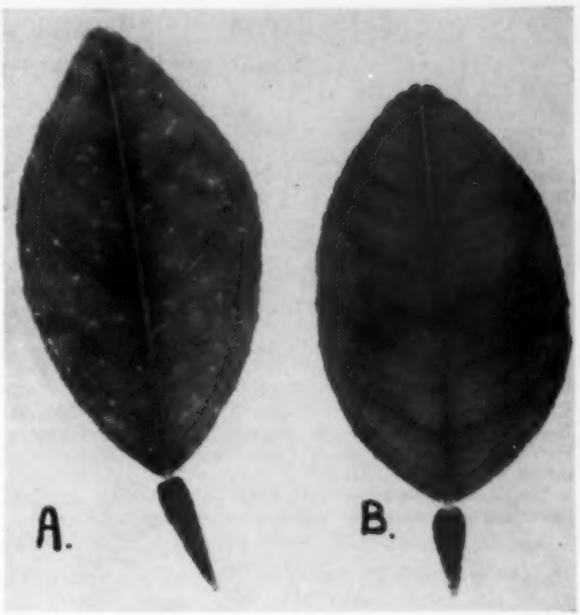

FIG. 1. A) Young leaf of Mexican lime seedling showing vein-clearing symptom of tristeza; seedling had previously been grafted with scion wood from Meyer lemon. B) Symptomless leaf from a nongrafted Mexican lime seedling.

With additional time the cleared areas increased in number and were distributed quite generally on both the main veins and the veinlets (Fig. 1). These symptoms are identical with those described in the literature as being typical of tristeza on this indicator plant.

The results of the inoculation experiments were as follows: total number of Mexican lime seedlings inoculated, 28; number of seedlings on which graft union was successful, 12; number of seedlings showing leaf symptoms, 12. No symptoms developed on 30 noninoculated seedlings maintained as controls.

This demonstration of tristeza in Meyer lemons in Israel is, as far as we know, the first experimental proof of the presence of the tristeza virus in the Mediterranean region. Other citrus varieties imported from countries where tristeza is present also may be infected. Such suspected varieties in Israel are now under test. The few Meyer lemon trees existing in Israel are being destroyed so as to remove this 1 known source of infection. So far, there is no indication that commercial citrus varieties, such as sweet orange or grapefruit on susceptible stocks, have become infected.—University of California Citrus Experiment Station, Riverside, California, and Agricultural Research Station, Rehovot, Israel.

[1] Contribution No. 124, Agricultural Research Station, Rehovot, Israel.

[2] Plant Pathologist, University of California Citrus Experiment Station, Riverside, California, and Consultant, U.S.O.M./Israel, 1955.

[3] Head of Division of Plant Pathology and Pathologists, respectively, Agricultural Research Station, Rehovot, Israel.

[4] Olson, E. O., and B. Sleeth. 1954. Tristeza virus carried by some Meyer lemon trees in south Texas. Eighth Ann. Rio Grande Valley Hort. Inst. Proc. 1954: 84-88.

[5] Wallace, J. M., and R. J. Drake. 1955. Tristeza virus in Meyer lemon. Calif. Citrog. 40(3): 84, 95-96.

[6] Wallace, J. M. 1951. Recent developments in studies of quick decline and related diseases. Phytopathology 41: 785-793.

[7] Bennett, C. W., and A. S. Costa. 1949. Tristeza disease of citrus. Jour. Agr. Res. 78: 207-237.

REPORT OF THE 47TH ANNUAL MEETING OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY

The American Phytopathological Society held its 47th Annual Meeting on December 27–30, 1955, at the Biltmore Hotel, Atlanta, Georgia, as a part of the 122nd Annual Meeting of the American Association for the Advancement of Science. Some 500 members were in attendance. The Council met on December 27, 28, and 30, and Society Business meetings were held December 28 and 30. A total of 185 formal papers of original research were presented in addition to several invitational Symposium papers. Three general Symposia were held: 1) The Cotton Plant, 2) The Tobacco Plant, 3) Plant Pathologists Can Use TV. Informal Conferences were held on 1) Nomenclature and Classification of Plant Viruses, 2) Extension Workers' Breakfast, 3) Oak Wilt, 4) Tomato Diseases, 5) Teaching Forest Pathology, 6) Stone Fruit Viruses, 7) Seed Treatments.

The annual banquet was held on Thursday evening, December 29, with 250 members attending.

Organization of American Phytopathological Society, 1956

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The Committee on Plant Disease Prevention was discontinued.

REPORTS OF OFFICERS

Report of the Secretary. As of December 31, 1955, the American Phytopathological Society has 1735 members, including 119 Life Members, 18 Emeritus Members, 3 Emeritus and Life Members, 13 Sustaining Associates, and 1582 Regular Members. Of the 1582 Regular Members, 226 are New Member Applicants of which 139 are students. Since our last meeting, word has been received of the death of the following members or former members: Vera K. Charles, T. F. Manns, Lucia McCullough, Donald Reddick, Bjarne Dundas, H. B. Humphrey, W. A. McCubbin, C .R. Orton, A. V. Osmun, C. O. Smith, and L. R. Tehon.

GLENN S. POUND, *Secretary*

Report of the Treasurer.

Receipts:		
Balance on hand, July 1, 1954	$ 8,771.83	
Membership dues	2,502.00	
Sales of Fungicide Data Summaries	571.10	
Total receipts		$11,844.93
Expenditures:		
Office of the Secretary	$ 621.82	
Office of the Treasurer	242.60	
Expenses, Placement Committee	24.13	
Expenses, Annual Meeting (Estes Park)	879.18	
Expenses, Publication of Fungicide Data Summaries	532.76	
Expenses, Public Relations Committee	235.00	
Dues, A.I.B.S.	1,000.00	
Donation to PHYTOPATHOLOGICAL CLASSICS	1,000.00	
Total expenditures		$ 4,535.49
Balance on hand, June 30, 1955		$ 7,309.44

SAUL RICH, *Treasurer*

Report of the Business Manager for *Phytopathology*.

Receipts:		
Balance on hand, June 30, 1954	$16,882.54	
Subscriptions and Member-Subscriptions	22,955.94	
Advertisements	4,195.88	
Sales of back issues	1,316.95	
Reprints and excess illustrations	6,077.09	
Sustaining Associate Memberships	1,300.00	
Donation, Rockefeller Institute	600.00	
Interest on investments	866.95	
Sales of investments	8,889.80	
Total receipts		$63,085.15
Expenditures:		
Manufacture and distribution of PHYTOPATHOLOGY	$17,936.88	
Cost of reprints	2,225.89	
Office of the Business Manager	1,084.58	
Office of the Editor-in-Chief	3,314.07	
Office of the Advertising Manager	490.16	
Cost of new investments	23,954.81	
Collector of Internal Revenue	728.35	
Refunds	113.20	
Miscellaneous	13.92	
Total expenditures		$49,861.86
Balance on hand, June 30, 1955		$13,223.29

SAUL RICH, *Business Manager*

INVESTED FUNDS OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY AND PHYTOPATHOLOGY

Amounts as of June 30, 1954. Dividends and Interest for Fiscal Year, July 1, 1954–June 30, 1955

Sinking Fund:	
U. S. Savings Bonds, Series G (2½%) (Interest—$25.00)	$ 1,000.00
U. S. Savings Bonds, Series F (at maturity)	1,150.00
Northwestern Fed. Sav. & Loan Ass'n. (certificate) (Div.—$95.00)	2,000.00
Family Finance Corp., common, 7 sh at par (Div.—$12.25)	7.00
Westinghouse Electric Co., 22 sh at cost (Div.—$55.00)	849.08
Standard Oil of Ohio, common, 50 sh at cost (Div.—$124.65)	2,018.65
American Cyanamid Co., common, 40 sh at cost (Div.—$80.00)	2,160.47
Johns-Manville Corp., common, 25 sh at cost (Div.—$106.25)	1,664.27
New Haven Savings Bank, on deposit (Interest—$4.84)	193.23
Total	$11,042.70
Lyman Memorial Fund:	
Westinghouse Electric Co., common, 35 sh at cost (Div.—$87.50)	$ 1,350.81
Am. Tel. & Tel., common, 16 sh at cost (Div.—$144.00)	2,490.47
Total	$ 3,841.28
***Phytopathology* Contingency Fund:**	
Johns-Manville Corp., common, 7 sh at cost (Div.—$29.75)	$ 466.00
Arlington & Fairfax Sav. & Loan Ass'n. (Interest—$278.30)	7,041.62
Prudential Bldg. Ass'n. (Interest $106.55)	6,060.20
Arundel Fed. Sav. & Loan Ass'n. (Interest—$302.70)	7,980.79
Southern Fed. Sav. & Loan Ass'n. (Interest—$295.00)	8,501.14
Decatur Fed. Sav. & Loan Ass'n. (Interest—$216.24)	7,696.57
Fidelity Fed. Sav. & Loan Ass'n. (Interest—$196.60)	7,153.28
Southwest Sav. & Loan Ass'n. (Interest—$122.50)	7,000.00
Lawn Sav. & Loan Ass'n. (Interest—$280.00)	8,000.00

Total	$59,899.60

SAUL RICH, *Treasurer and Business Manager*

Report of the Auditing Committee. On August 8, 1955, the undersigned examined the books of the American Phytopathological Society and of PHYTOPATHOLOGY covering the period July 1, 1954–June 30, 1955. All receipts, expenditures, and funds were found to be accurately recorded and in order.

A. W. FELDMAN
P. J. ANDERSON
J. S. TIDD

Report of the Advertising Manager. From October, 1954, through September, 1955, there were 86.5 advertising pages with 102 paying advertisements. The gross income was $4,045.65, with a balance of $3,753.34 after agency commissions and cash discounts were deducted. Expenses of the advertising manager were postage and telegraph charges of $45.39 and $72.00 for stenographic assistance. The commission to the advertising manager amounted to $325.33, making a total of $442.72 in expenses.

Total income to the Society is $3,310.62

LEONARD J. ALEXANDER, *Advertising Manager*

Report of the Business Manager of *Phytopathological Classics*. The number of copies of Phytopathological Classics sold during the fiscal year, July 1, 1954, to June 30, 1955, was 101 having a total value of $115.75. Number of classics on hand June 30, 1955: No. 1, 500; No. 2, 524; No. 3, 38; No. 4, 120; No. 5, 338; No. 6, 392; No. 7, 335; No. 8, 519; No. 9, 743.

Receipts:

Cash balance on July 1, 1954		$ 806.96
Received during fiscal year 1954-55:		
From sale of Classics:		
Originals	$ 79.00	
Reprints	1.50	
On accounts due:		
Originals	21.75	
Overpayment on Classics	0.50	
From Society for reprinting:		
No. 1 and 2	1,000.00	
	$1,102.75	$1,909.71

Disbursements:

Postage	$ 10.50	
Cost of reprinting Classics No. 1 and 2	382.52	
Cash balance on June 30, 1955	1,516.69	$1,909.71
Due on accounts June 30, 1955:		
Present fiscal year:		
Originals	$ 33.50	
Reprints	2.25	
Previous fiscal year:		
Originals	25.50	
Total due on accounts	$ 61.25	

CARL W. BOOTHROYD, *Business Manager*

Report of the Editor of *Phytopathological Classics*. The last number published in the PHYTOPATHOLOGICAL CLASSICS series was Tozzetti's "True nature, causes, and sad effects of the rust, the bunt, the smut, and other maladies of wheat and of oats in the field." Since issuance of PC 9 in 1952, plans for the next issue have been held in abeyance pending accumulation of funds from sales of previous numbers. Adequate financing now appears assured for the printing of PC 10.

Consideration is being given, in the planning of PC 10, to a proposal made by Dr. G. C. Ainsworth, who suggests that the centenary of the death of Agostini Bassi be celebrated by publishing in English his 2 classic papers in early microbiology, "Del mal del signo," 1835 and 1836. Other suggestions for titles in the PC series continue to be welcomed.

L. C. KNORR, *Editor*

Report of the Editor-in-Chief. Thanks to the excellent planning and direction of the retiring Editor-in-Chief, Dr. W. C. Price, the change in editorship was made gradually and smoothly, with a minimum of confusion. I am very grateful to Dr. Price for his help, which began several months prior to January 1, 1955, and continued for several months afterward.

Subsequent to the period covered by the 1954 report, PHYTOPATHOLOGY has published 2 articles intended as aids in the preparation and editing of papers for PHYTOPATHOLOGY. Dr. Price's article on preparing manuscripts, which appeared in the December issue of Volume 44, has had a noticeably salutary effect. Many submitted manuscripts bear unmistakable evidence of the authors' close attention to the information contained in this article. It is unfortunate that this is not true for all manuscripts. Failure to make use of this information slows down the editing of papers, thereby delaying publication; results in an excessive amount of alteration and markings for the printer, thereby increasing the number of printing errors; and increases the amount of editing, thereby increasing the cost to the Society. The article by S. E. A. McCallan, L. P. Miller, and Mary A. Magill on active ingredients of fungicides, which appeared in the June issue of Volume 45, has done much to correct the confusion and inaccuracies that have existed in reports on trade-named fungicides. Authors are urged to make use of the information provided and to follow the exact spellings listed in this article. The Council authorized printing of a good supply of reprints of both of these articles. These reprints are available from the authors or from the office of the Editor-in-Chief.

Material published in the October, November, and December issues of Volume 44, which could not be included in the 1954 report of the Editor-in-Chief, consisted of 172 pages of technical material, 1½ pages of News, 22½ pages of advertising matter, a 27-page index, and a list of errata. Included in the technical material were 36 articles, 6 Phytopathological Notes, Dr. Price's article on preparing manuscripts, 1 note for the Interdepartmental Committee on Pest Control, and the Report of the 46th Annual Meeting of the Society.

Volume 45 contains 696 pages of technical material, 6 pages of News, 94 pages of advertising matter, a 16-page index, and a list of errata. The technical material is comprised of 128 articles; 6 symposium papers; the article by McCallan, Miller, and Magill on active ingredients of fungicides; 33 Phytopathological Notes; 6 obituaries; the report and 22 abstracts for the tenth annual meeting of the Northeastern Division; the report and 31 abstracts for the annual meeting of the Southern Division; the report and 18 abstracts for the twelfth annual meeting of the Potomac Division; 1 notice for the Chemical-Biological Coordination Center; 1 note for the Special Committee on Fungicide Nomenclature; 1 notice for the Society concerning the forty-seventh annual meeting; and 7 book listings. On November 29, the January issue was ready for printing, and 98 manuscripts were in the process of being edited. Of these, 13 were in the hands of reviewers, 4 were being edited in this office, 27 had been returned to authors for revision, 31 were at the printer's and 23 were in galley proof. From October 1, 1954, to November 29, 1955, a total of 20 manuscripts were rejected by the editors or withdrawn by the authors.

I am pleased to acknowledge the continuing financial assistance of the Rockefeller Institute for Medical Research and of the Sustaining Associates of the Society. I wish

to express my appreciation to Mr. John Ferguson, 3rd, and staff of the Monumental Printing Company for their excellent craftmanship and cooperation, to the Editors and Associate Editors for their very fine reviews, to the Business Manager and other officers of the Society for their unfailing cooperativeness, to Mrs. Carroll E. Cox for the capable indexing of Volume 45, and to all contributing authors for the generally high quality of their work—and for their forbearance with a new editor.

A. F. Ross, *Editor-in-Chief*

Report of the Editor of News. During 1955, a half page of news was published in each number of the Journal. Items have reached the editor's desk in sufficient volume to reduce the amount of soliciting previously required. However, there are still a number of institutions where members are either reticent to supply items of interest concerning themselves, or their colleagues are negligent in this respect. The Editor has requested certain individuals at several such institutions to act as unofficial reporters and send in items that might be of interest to the membership of the Society. It is hoped that this will improve both the quality and quantity of news items published in the future. After 7 years of handling the news section himself, your Editor feels that this section of the Journal has become established and that some thought should be given to perpetuating it in the event anything happened to the Editor. Perhaps the Editorship of the news section could be handled within the framework of a committee such as the Publicity Committee. By such a procedure, such responsibility for Editorship of the news section could be assigned without too much disruption, should the need or desire arise.

K. W. Kreitlow, *Editor*

Reports of Standing Committees

Report of the Committee on Donations and Legacies. After considering the merits of each request for gratuitous subscription to Phytopathology, the Committee recommends continuation in 1956 of 7 of the 10 subscriptions that were in force in 1955, and the approval of 2 new requests. The names of the recipients recommended are 1) The American Institute of Biological Sciences, % the Managing Editor, AIBS Bulletin, Washington 25, D. C.; 2) Centro de Documentacion Cientifica y Tecnica, Dr. A. Perez, Vitoria, Director, Plaza de la Ciudadela 6, Mexico, D. F.; 3) William B. Brierley, University of Reading, Reading, England; 4) K. Minev, Plant Pathology Department, Faculty of Agriculture, Skopje, Macedonia, Yugoslavia; 5) H. Pape, Institut for Getreide, Olfrucht and Futterpflanzenbau, Schlosskoppelweg 8, Kitzeberg bei Kiel, Germany; 6) Jaroslav Peklo, Chodska 311, Prague XII, Czechoslovakia; 7) J. A. Sarejanni, Phytopathologique Banaki, Athens, Greece; 8) Permanent Exhibit at the Rectorate, Prof. Dipl. Ing. Alfred Heim, Secretary of the Committee, University of Zagreb, Marshall Tito Square 3—Postbox 89, Zagreb, Yugoslavia; 9) the Jewish National and University Library, C. Wormann, Director, P. O. Box 503, Jerusalem, Israel.

Lee M. Hutchins, *Chairman*

Report of the Committee on Finances and Investments. Our total invested funds of $74,783.58 earned $2,562.13, a yield of 3.4 per cent.

Common stock holdings which originally cost $10,099.75 returned $627.15, a yield of 5.7 per cent. The value of our stock as of closing on 9/19/55 was $14,338.63. We bought no new stock this year.

Our federally insured Savings and Loan accounts total $61,433.60. Dividends and interest from these accounts were $1,892.89, a yield of 3.1 per cent.

The following 3 per cent S & L accounts were closed: Perpetual ($1,465.01), District ($2,192.41) and Jefferson ($732.38). The following withdrawals were made from accounts which approached the $10,000 insured limit: $1,500 from Arundel, and $3,000 from Arlington-Fairfax. All account closures and withdrawals were made at the close of the interest period ending 12/31/54. The following deposits were made in S & L accounts at the start of the interest period which began 1/1/55: $4,454.81 in Prudential, $1,500 in Decatur and $3,000 in Fidelity. The 2 new S & L accounts opened this past fiscal year are $7,000 (on 1/3/55) in Southwest and $8,000 in Lawn on 7/7/54. No interest was lost in any of these transactions. All our S & L accounts are currently paying 3 per cent except for Northwestern Federal, which pays 3.25 per cent.

The balance of our invested funds are in U. S. Savings Bonds ($2,150), in 7 shares of Family Finance Corporation, and on deposit in the New Haven Savings Bank ($193.23 as of 6/30/55).

The Society is in a tax category which allows a $1,000 exemption for unrelated business income. Any amount in excess of $1,000 (up to $25,000) is taxed 30 per cent. Last year, a 9-month return was filed (10/1/53 to 6/30/54) in order to make our tax year coincide with our fiscal year. For the 9-month period we payed an income tax of $61.97. For the fiscal year ending 6/30/55, we will be obliged to pay $468.64.

Further details are in the Chairman's hands and will be furnished on request.

R. H. Wellman, *Chairman*

Report of the Committee on International Cooperation. The Committee has not met during the past year, but several Committee members have met incidentally from time to time and have discussed problems and prospects.

Several of the individual members of the Committee have helped promote international cooperation in various ways, partly in their official capacity and partly because of their committee membership.

The chairman of the Committee has tried to ascertain the sentiment of various Committee members on an opportunistic basis and, as chairman, has promoted certain activities in the name of the Committee.

Special attempt has been made to stimulate interest in and cooperation with the disease and pest reporting service of the Food and Agriculture Organization.

One of the Committee members, K. Starr Chester, as a member of the International Commission on Plant Disease Losses, has been instrumental in stimulating the work on plant disease appraisal, which is carried on principally by E. C. Large, as Secretary of the Commission.

Other Committee members, such as H. A. Rodenhiser, J. G. Harrar, and G. H. Coons, have helped arrange for international cooperation in exchange of information and materials in special fields, especially in the Western Hemisphere. The international wheat rust nurseries, as an example, which are under the general supervision of Dr. Rodenhiser and in which the Rockefeller Foundation is collaborating, were commended highly in a resolution adopted by the III Reunion Latinoamericana de Fitogenetistas, Fitopatologos, Entomologos y Edafologos.

At the III Reunion, Committee members J. G. Harra, H. A. Rodenhiser, and E. C. Stakman were present, participated in the discussions, and helped the phytopathological section make plans for cooperation on plant pathological problems in Latin America, particularly the cooperative testing for varietal resistance to certain diseases of the most important crop plants and cooperative tests on fungicides, and on various other problems which are regional in nature.

Virtually all members of the Committee were active in helping people from many other countries obtain materials and literature on special subjects and tried to help people

with similar problems in various countries to communicate with each other.

The idea of regional tests and meetings was promoted as much as possible, almost always, however, on an opportunistic basis.

Recommendations

The consensus of the Committee is that effort should be concentrated on the following activities for 1956:

1) Continued and improved cooperation with the disease and pest reporting service of the FAO (Dr. Ling)

2) Cooperation with the International Commission on Plant Disease Losses

3) Cooperation with the Comite Fitopathologico Latin-Americano de Cooperacion, which was organized at the III Reunion in Colombia during June, 1955. The organization of this committee is given below.

Chairman.—J. A. B. Nolla, Mayaguez, Puerto Rico

Sub-committee for Tropical Crops.—Ricardo Cardenosa, Palmira, Colombia (chairman); Rodrigo Orellana, Turrialba, Costa Rica; Karl Silberschmidt, Sao Paulo, Brazil

Sub-committee for Temperate Zone Crops.—Jose Vallega, Castelar, Argentina (chairman); John Niederhauser, Oficina de Estudios Especiales (RF), Mexico; H. A. Rodenhiser, U. S. Department of Agriculture

Special Adviser to the Committee.—Lee Ling, FAO, Rome

General Adviser to the Committee.—E. C. Stakman, University of Minnesota and the Rockefeller Foundation

H. A. Rodenhiser, Lee Ling, and E. C. Stakman are members of the APS Committee on International Cooperation and were requested to act as member and as advisers, respectively, to the Latin-American Comite. This should provide for coordination between the activities of the 2 committees and should make it possible to obtain more concrete results. It is recommended that the chairman of the committee, J. A. B. Nolla, be appointed a member of the APS Committee on International Cooperation in order to bring about even closer cooperation.

4) The question of exchange of publications will be studied by the committee during the ensuing year.

5) The Committee will also look for opportunities to cooperate closely with certain other organizations, such as the European Plant Protection Organization and the new Organismo Internacional Regional de Sanidad Agropecuaria (OIRSA), which was formed by the governments of Mexico, Costa Rica, El Salvador, Nicaragua, Honduras, Panama, and Guatemala for the purpose of undertaking and coordinating investigations and the control operations in the field of plant protection as well as animal health.

Specific Recommendations

1) *Approval of Program.* It is recommended that the program outlined above be approved, with any additional mandates or suggestions that the Council may wish to give the Committee.

2) *Committee Membership.* It is recommended that the present members of the Committee be reappointed, as continuity is desirable, and that J. A. B. Nolla be added, for reasons given previously.

E. C. Stakman, *Chairman*

Report of the Placement Committee. During 1955, 51 plant pathologists have had their applications in the active files of the Placement Committee. Request from prospective employers for applicants to fill 33 positions have been received. One hundred seven applications have been sent out to 23 employers.

Incomplete records show that at least 4 plant pathologists have obtained positions during 1955 through the efforts of the Committee.

Edwin E. Honey, *Chairman*

Report of the Committee on Public Relations. The work of this Committee continued along the lines initiated last year, namely that of publicizing some of the outstanding plant disease research papers. Eighteen articles have been prepared and published in the major farm magazines, including The Farm Journal, Agricultural Leaders Digest, Agricultural Chemicals, Successful Farming, and The American Nurseryman. In addition to the above mentioned articles, our writer, Robert Rathbone, has made possible the presentation of certain phases of our pathological activities through official channels. Press releases covering about 25 papers that seem to have publicity value will be issued at the time of their presentation at Atlanta. Excellent coverage of material published in Phytopathology has resulted through the courtesy of the Editor, who has made galleys available 2 months prior to publication.

The effectiveness of our program would be materially enhanced if more of our Society members would participate by submitting copies of their articles to us when they are accepted for publication, since timing is an important factor in public relations work.

Paul R. Miller, *Chairman*

Report of the Committee on Plant Disease Prevention. The Committee, in its report last year, referred to growing international concern over the spread of plant pathogens to and between Pacific Islands. A conference on the subject was held at Singapore on December 13–17, 1954, under the auspices of FAO. A proposed agreement was drafted under which the countries of Southeast Asia and the islands of the Southwest Pacific will adopt uniform regulations to govern the movement of plant material from tropical America; especially rubber plants to prevent the introduction of the South American leaf blight. The proposed agreement is now under consideration by the Council of FAO, prior to being submitted to the governments concerned for signing and ratification.

Meanwhile, under FAO leadership, the governments of Central America and Mexico have formed an organization ("OIRSA") directed toward the improvement of plant protection measures in that region.

On the home front it may be of interest to note that buckthorn has, at long last, been added to the noxious weeds listed by the Iowa weed law.

E. B. Lambert, *Chairman*

Report of the Committee on Regulatory Work and Foreign Plant Diseases. The Committee members present at the 46th annual meeting held an informal meeting at Estes Park, Colorado, August 27, 1954. A special meeting of the Committee was held in Washington, D. C., January 28, 1955, in conjunction with federal regulatory officials of the United States Department of Agriculture and representatives from the Society of Industrial Microbiologists. Proposed legislation pertaining to plant quarantine, financial support for activating virus indexing, and other matters were considered. Dr. R. P. White was absent; all other Committee members were present. (Travel expenses of Committee members were paid by other agencies or personally by the members.) Minutes of the Committee deliberations are on file with the chairman.

The following resolutions were submitted to the Council, American Phytopathological Society, for consideration and action following the Washington meeting.

I. RESOLUTION PERTAINING TO AMENDMENT OF CROP PEST ACT 1905

"Resolved that the committee approve the proposed Amendment to the Insect Pest Act of 1905 in principle and recommend that consideration be given by the administrators of the Crops Regulatory Programs to a statement of the method of operating under this act in the Department of Agriculture whereby matters of controversy may be referred to technical, including research, experts in the field before a final decision is made."

II. RESOLUTION RECOMMENDING THE APPROPRIATION OF FUNDS TO CONDUCT THE INDEXING FOR VIRUS DISEASES OF FRUIT PLANTS ON AN ADEQUATE BASIS

Whereas, the Interregional Technical Committee for Stone Fruit Virus Research recommended the establishment of an indexing for viruses of stone fruit trees imported for experimental use,

And whereas, the American Phytopathological Society approved the following resolution at their annual business meeting and transmitted a copy of the resolution to the regulatory and fruit research officials of the United States Department of Agriculture:

"*Whereas*, the procedure of visual inspection is now considered inadequate for protection from viruses in plant materials, it is suggested that modifications be made to give greater safeguards and more expeditious handling.

"For tree fruits, it is well known that indexing procedure is necessary for detection of many viruses and is better by far than is visual inspection. Therefore, it is suggested that index procedure be instituted for all fruit plant materials being introduced and propagated at the Glendale isolation station or any substations thereof before they are placed in use. For example, for stone fruit materials, if the plants are indexed on appropriate hosts, as listed by the Interregional Subcommittee on 'Host Range Studies on Virus Diseases of Stone Fruits,' it would be considered that adequate precautions will have been taken."

And whereas, there is need of a pathologist trained in the field of plant viruses to put the indexing program into full effect,

Therefore, the Council of the American Phytopathological Society recommends the appropriation of new monies by the Congress to make possible the appointment of a plant pathologist to conduct this regulatory work of indexing and in addition to conduct research on methods of indexing other groups of plants imported for research purposes.

The importance of the indexing is set forth in the original resolution.

The Council approved these resolutions by a majority vote and the proper officials were notified by the Secretary. The committee chairman also notified the chairman of special committees appointed by the Mycological Society of America and the Society of Industrial Mycologists on the action taken by the Council of the Society regarding the amendment of the Insect Pest Act of 1905 (Resolution I. above).

The amendment to the Insect Pest Act of 1905 to include plant pathogens will be before the Congress probably in the 1956 spring session.

The committee has recommended that the Regulatory officials prepare a suitable digest of the legislation, including instructions on operation in conformity with the legislation, for circulation and publication after the amendment has been enacted

The plant pathologist to assist in virus indexing is in the process of being employed.

The committee presents the following resolution to the Council as a memorandum of instruction and as a definition of committee responsibility; first to the American Phytopathological Society and second to the Regulatory agencies of the federal government and states. The committee recommends approval of the resolution in its present form or as it may be modified by the action of the Council to define more clearly committee responsibilities and committee procedures.

III. RESOLUTION DEFINING THE RESPONSIBILITIES, FUNCTIONS, AND PROCEDURES OF THE COMMITTEE ON REGULATORY WORK AND FOREIGN PLANT DISEASES OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY.

Whereas, the committee was established at the request of Regulatory officials of the United States Department of Agriculture,

And Whereas, no official action of the American Phytopathological Society defining and instructing said committee can be found in the official minutes and actions of the Society,

And Whereas, said committee has been and now is serving as an advisory body to the federal and state agencies enforcing regulatory legislation pertaining to plant phytopathological problems and frequently must define principles and advise on policies,

Therefore, the committee respectfully requests the Council of the American Phytopathological Society to define responsibilities and approve methods of procedure of said committee as outlined or as modified by Council and Society action.

1) The Committee on Regulatory Work and Foreign Plant Diseases shall represent the American Phytopathological Society in an advisory capacity on international, national, and state problems and policies pertaining to the regulatory aspects of plant disease problems.

2) The Committee is authorized to receive, to discuss, to advise on, and to formulate tentatively opinions and policies pertaining to plant disease regulatory problems, including matters related to the introduction or importation of foreign plant materials and plant disease material and pathogens, the interstate movement of such materials and pathogens, and regulatory policies and decisions pertaining thereto. The Committee shall furnish data, information, technical advice, and their counsel and study of such matters.

3) In performing the above-mentioned functions for the Society, it is specifically understood (a) that the committee shall serve as an advisory and fact-finding body on technical problems in plant pathology, such advice and information to be given direct to the Crops Regulatory Programs of the United States Department of Agriculture and to States, Commonwealths and Territories; (b) that the committee is responsible directly to the Council of the Society and that the committee shall transmit all recommendations involving national policy to the Council for approval; (c) that the committee action on policy matters is not to be construed as official by any agency; and (d) the Council of A.P.S. hereby assigns to the committee the responsibility of distinguishing between requests for information and requests for advice on matters pertaining to policy.

JAMES G. DICKSON, *Chairman*

Report of the Committee on Seed and Plant Material Certification. The program of this committee, described in a previous progress report (P.D.R. 38 (7): 521-528, 1954), had to be modified owing to lack of response to the national request for information from pathologists. In lieu of general participation and assistance, the problems are being studied by the subcommittees under guidance of the chairmen who are in turn members of this parent committee. Studies in progress in 1955 were concerned with analyses of seed-borne diseases and pathological standards in forage crops, vegetables, cereals, southern crops, stone fruit crops, and ornamentals. Highlights of this year's work are 1) near-completion of a comprehensive report on development and production of pathogen-free propagative material for certain ornamental plants; 2) progress in development of techniques for detection of loose smut infection in wheat seed; 3) organization of a project for assembling, maintaining, and dispersing of stone fruit stocks free of virus diseases; and 4) intensive study of pathological standards in several southern crops, particularly sweet potato. Close contact is being maintained with the Committee on Pathological Standards of the International Crop Improvement Association, and results of our studies will be submitted to that organization as soon as available.

JOHN R. HARDISON, *Chairman*

Report of the Committee on History of Plant Pathology. This Committee completes its first year of

activity at this time. Its duty as defined for it was to "collect and conserve items of historical significance to the profession of plant pathology." To carry out this plan, a file has been set up in the National Fungus Collections at the Plant Industry Station, Beltsville, Maryland, to receive all pertinent material as it becomes available. A brief note requesting such material appeared in "News Notes" in Phytopathology and a more comprehensive one in the October issue of the Plant Disease Reporter.

Dr. LeClerg, who has long been pressing for action in this field, has deposited material which he had collected. Dr. Max Gardner has made contributions, and it is planned to add pertinent material from the papers of C. L. Shear, a founding member and first secretary of the Society. Dr. Curtis May has made available Society records which he had accumulated during his term as secretary and which included the records of a number of his predecessors. Dr. Maramorosch, a member of the committee, plans in due time to provide for the records copies of his photographs of the Society membership. Retired members, particularly past officers, will be asked to deposit with us anything of possible interest.

This collection of material becomes, in effect, the Archives of the Society, and will be available in due time for the historian who will set out to prepare a history of phytopathology, and in particular, of the part the American Phytopathological Society has played therein.

JOHN A. STEVENSON, *Chairman*

Report of the Committee on Resolutions. Be it resolved that the American Phytopathological Society in solemn assembly at their 47th Annual Meeting at Atlanta, Georgia, on December 30, 1955, do hereby convey their heartfelt thanks to 1) the Committee on Local Arrangements (Julian H. Miller, Chr., W. A. Campbell, Lytton Boyle, A. A. Nikitin, J. A. Pinckard) for a splendid performance, 2) the officers of the Society for doing their chores, 3) the Council for long long hours spent haggling over details, 4) the Atlanta Biltmore for its gracious Southland hospitality, 5) the Southern Division for foregoing its usual annual meeting with the Southern Agricultural Workers, and meeting with us, thereby adding much success to our meeting.

RODERICK SPRAGUE, *Chairman*
T. H. KING
C. H. ARNDT

Report of Elections and Appointments. A Committee was appointed by the Council to count the ballots for the election of new officers. The following were declared elected: President Elect, George W. Fischer; Vice President, Paul R. Miller; Councilor-at-Large, S. E. A. McCallan.

Upon recommendation of the Council, the Society approved the appointment of Saul Rich for a second 3-year term, beginning January 1, 1956, as Treasurer of the Society and Business Manager of Phytopathology; of F. O. Holmes as Editor; and of Carl Eide, A. B. Groves, L. C. Knorr, and Roderick Sprague as Associate Editors of Phytopathology, each for a 3-year term beginning January 1, 1956.

Representatives and Committees as listed above were appointed and approved.

The Society approved recommendations of the Council as follows:

1) That $100.00 be granted to the Division of Biology and Agriculture, NRC, to help defray expenses of publication and free distribution to High Schools and Junior Colleges of the "Career Booklet in Biology."

2) That $500.00 be granted to the American Type Culture Collection to help defray expenses connected with production of their new catalog.

3) That the sum of $1,735.00 be contributed to the AIBS instead of the $1,000.00 required in order to assist in additional services by AIBS.

4) That the $1,500.00 allocation granted to the Public Relations Committee for each of the past 2 years be renewed and placed on a continuing basis to be reviewed annually.

5) That the Committee on Publication of Special Material consider the publication of a series of monographs of important diseases, to choose an author or authors and subject or subjects, and be authorized to mention to a prospective author a figure up to $2,000.00 as a Grant-in-Aid and to report back to the Council any specific proposal or proposals for final clearance.

6) That $7,500.00 be set up as a fund for use in observance of the Society's 50th Anniversary in 1958.

7) That the Phytopathology News Sheet be prepared by a Standing Committee to be appointed by the Council and to be composed of a Chairman, who will also serve as Editor, and 1 member from each of the 5 Divisions of the Society and 1 from Canada. The Committee is authorized to increase its space use in Phytopathology to a full sheet as needed. Members of the Committee are listed above.

8) That all activities of Phytopathological Classics be combined in a Single Standing Committee. Members of the Committee are listed above.

9) In commemoration of the 200th Anniversary of the birth of Prévost the following resolution was unanimously adopted:

IN COMMEMORATION: ISAAC-BÉNÉDICT PRÉVOST
1755–1819

Whereas, the year 1955 marks the 200th anniversary of the birth of Isaac-Bénédict Prévost, and

Whereas, his discovery of the immediate cause and a means of prevention of the bunt disease of wheat gave to the world a key to understanding the causation and the prevention of infectious diseases, and

Whereas, this discovery ranks high among the great pioneering advances in science,

Therefore, be it resolved

That the American Phytopathological Society express its deep sense of appreciation of the selfless devotion and the epochmaking contribution of this modest man who was denied in his lifetime the appreciation that he so richly deserved, and

That a biographical sketch of Prévost and an evaluation of his memoir on bunt be published in Phytopathology.

Future Meetings. The annual meeting in 1956 will be at the Netherland Plaza Hotel, Cincinnati, Ohio, on December 6, 7, 8 in conjunction with the Annual Meeting of the American Potato Association.

The annual meeting in 1957 will be held at Stanford University, Palo Alto, California, in early September in conjunction with the meetings of the AIBS.

The annual meeting in 1958 is tentatively scheduled to be held at the University of Indiana, Bloomington, Indiana, in conjunction with the meetings of the AIBS.